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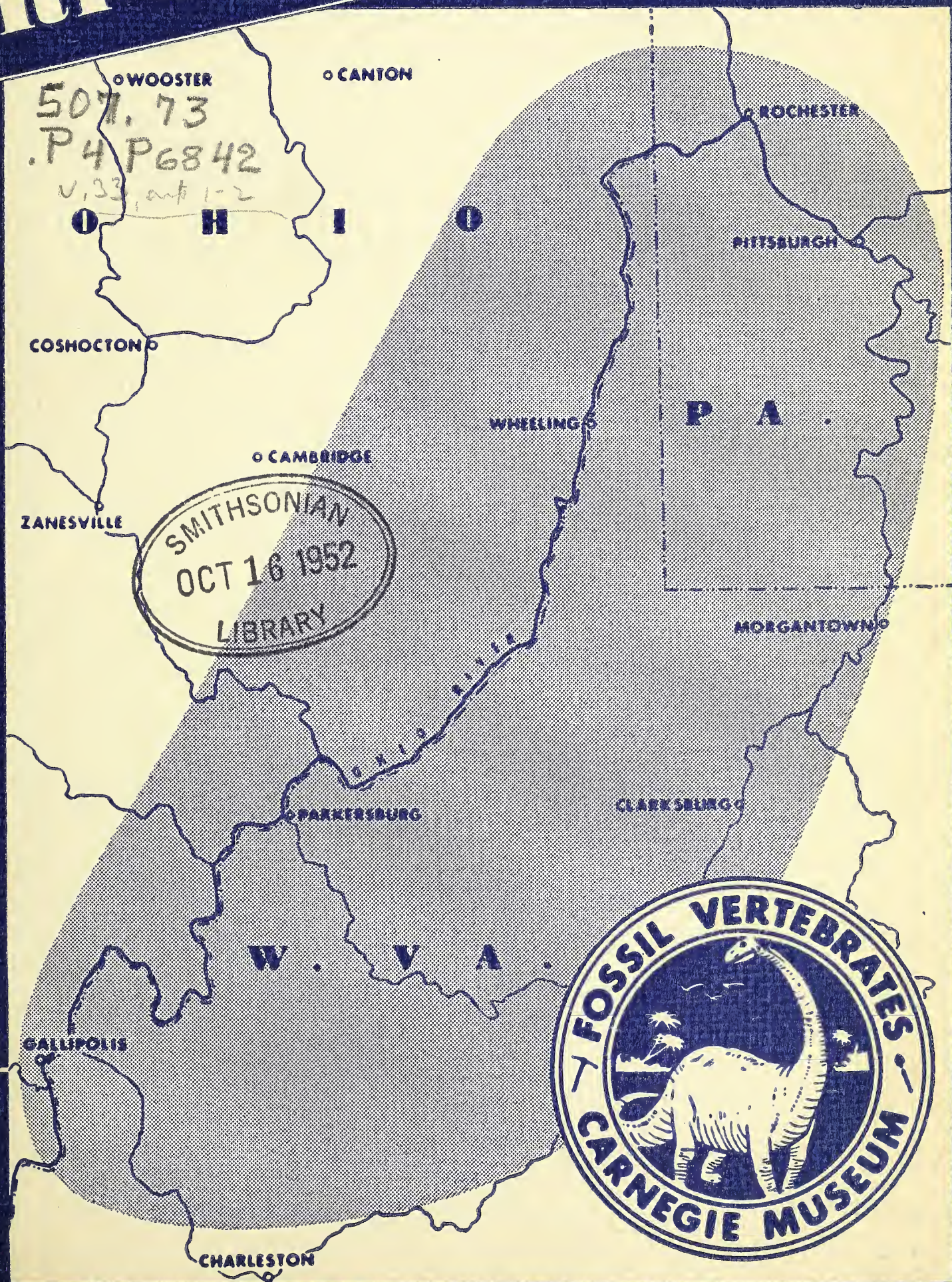
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FOSSIL VERTEBRATES of the TRI-STATE AREA



FOSSIL VERTEBRATES OF THE TRI-STATE AREA

Art. 1. LOCATION AND STRATIGRAPHY OF KNOWN
OCCURRENCES OF FOSSIL TETRAPODS IN THE UPPER
PENNSYLVANIAN AND PERMIAN OF PENNSYLVANIA,
WEST VIRGINIA, AND OHIO

BY WILLIAM E. MORAN
Arlington, Va.

Art. 2. LATE PENNSYLVANIAN AND EARLY PERMIAN
VERTEBRATES OF THE PITTSBURGH-WEST VIRGINIA
REGION

BY ALFRED SHERWOOD ROMER
Director, Museum of Comparative Zoölogy
Cambridge, Mass.

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ART. 1. LOCATION AND STRATIGRAPHY OF KNOWN
OCCURRENCES OF FOSSIL TETRAPODS IN THE UPPER
PENNSYLVANIAN AND PERMIAN OF PENNSYLVANIA,
WEST VIRGINIA, AND OHIO*

By WILLIAM E. MORAN

INTRODUCTION

This paper presents geological and geographical descriptions of those localities in Ohio, Pennsylvania and West Virginia, at which tetrapod fossils were collected by field parties of Carnegie Museum during the years from 1934 to 1937. A brief summary of all localities discovered earlier is included in this description, and the positions of both the new localities and those previously known fossil occurrences are indicated on the map accompanying this paper.

Early in the spring of 1934 several short collecting trips were made into West Virginia, followed in succeeding years by field parties of Carnegie Museum under the direction of John J. Burke. These parties included Eugene Burke in 1935, Charles T. Agostini in 1936 and 1937, and the writer in all of those years. The success in finding these new localities in a region where so few tetrapods had been previously found was in a large part due to the able leadership and persistence of John J. Burke. The first account of these finds was made by him in *Science* (1935: 153) and later he wrote a popular article about the collection for the *Carnegie Magazine* (1937: 145-149).

In the field a much greater amount of time was devoted to searching for additional localities than was spent making thorough investigations of a few places. The reasons for the continued search for new localities were to determine just how widespread these vertebrate occurrences were and to attempt to find places where the fossils were better preserved and less fragmentary. When the localities were found it was planned to re-visit them and make further collections and field notes, but these plans were not carried out. Consequently, the field notes are in many instances quite incomplete, in some cases furnishing only the geographical locations and the kind of matrix in which the fossils occurred.

The collecting that can be done in southwestern Pennsylvania, northwestern West Virginia, and eastern Ohio, is rather restricted.

* The major portion of this paper was presented as a thesis for the degree of Master of Science at the Columbian College of the George Washington University, Washington, D. C., in February 1942.

Good outcrops are generally scarce and are found along road cuts and steep banks of streams. The exposures are usually of small extent, both laterally and vertically, and are frequently partly covered with residual soil, thus making difficult the identification of individual strata. Further, some of the beds of thin limestone in which fossils were found are apparently not lithologically constant.

The stratigraphic identifications of fossiliferous beds are based largely on information given in the publications of the U. S. Geological Survey and of state geological surveys of West Virginia, Pennsylvania and Ohio. Often the identifications are based upon the elevations which were taken from contours on topographic maps of the U. S. Geological Survey and are, of course, subject to some error. In a region such as the one here concerned, where thin fossiliferous limestones lacking distinguishing characteristics are closely spaced stratigraphically, an error in elevation can easily cause considerable confusion in the identification of those beds. Consequently, the identification of fossiliferous strata described in this paper are in many cases uncertain.

ACKNOWLEDGEMENTS

I wish to express my appreciation for the opportunity afforded me by the late Dr. Andrey Avinoff, former Director of Carnegie Museum, and by Dr. J. LeRoy Kay, Curator of Vertebrate Fossils, at that institution, to write this paper concerning collections made by Museum field parties. I am very grateful to John J. Burke for his kind aid and for the many helpful suggestions he has given me throughout the work on this report. I am indebted to Dr. Alfred S. Romer, Director of the Museum of Comparative Zoölogy at Harvard University, for having permitted me to use his list of provisionally identified specimens from the Carnegie Museum localities. I wish to thank Dr. R. S. Bassler, who as head of the Department of Geology of the George Washington University, gave me advice in preparing portions of this paper. Dr. C. L. Gazin of the National Museum has very kindly read parts of this paper and has given much helpful criticism. I also wish to acknowledge the information given me by Wilber Stout, the State Geologist of Ohio, in regard to the stratigraphy at locality no. 6. John P. Nolting, Jr., Assistant Geologist of the West Virginia Geological and Economic Survey, very helpfully gave me information concerning the stratigraphy of locality no. 5. The late Dr. I. P. Tolmachoff, Curator Emeritus of Invertebrate Paleontology at Carnegie Museum, suggested and encouraged the preparation of this report.

GEOGRAPHY

The region with which this paper is concerned lies in southwestern Pennsylvania, northwestern West Virginia and eastern Ohio. In Pennsylvania the new fossil localities were found from Pittsburgh south and west to the West Virginia state line. The section of West Virginia which yielded vertebrates was much larger, extending from the northern part of Marshall County southwest into northern Putnam County, and east into western Monongalia County. The one new locality found in Ohio is in eastern Monroe County.

The area in which the collection was made is long and narrow, having a length in a general northeast-southwest direction of about 160 miles and a width in a northwest-southeast direction of about 40 miles. Locality no. 1 at Pittsburgh, Pennsylvania, is the most northern and the easternmost while locality no. 12 near Liberty in Putnam County, West Virginia, is the southern and westernmost. However, the older localities, which were found previous to the Carnegie Field Parties of 1934-1937 and which are briefly mentioned under "Previous Work" in this paper, do not all lie within this area.

The drainage of the region is tributary to the Ohio and Monongahela rivers. The Ohio and its lesser tributaries drain the northwestern part of the area while in the southwestern portion the drainage into the Ohio is largely by the Kanawha and the Little Kanawha rivers and their tributaries. The Monongahela river and its eastward flowing tributaries drain the eastern section of the area.

On the map of *Physical Divisions of the United States* by Nevin M. Fenneman and Douglas W. Johnson (1930), the area is included in the Kanawha Section of the Appalachian Plateaus Province of the Appalachian Highlands and is described as a "mature plateau of fine texture; moderate to strong relief."

GENERAL GEOLOGY

The outcropping rocks of this region are sedimentary deposits of shales, sandstones, limestones and coals of Pennsylvanian and Permian ages. The Pittsburgh series of the Pennsylvanian includes in ascending order the following groups: Allegheny, Conemaugh and Monongahela, all of which are found exposed in this area.

Overlying the Pittsburgh series is the Dunkard series, which includes two groups, the Washington and the Greene, these being the youngest

of the eastern Paleozoic deposits. The Dunkard series has generally been considered to be of Permian age and is so treated in this paper.

The general limits of the Dunkard series are shown in outline on the map of localities accompanying this paper. These limits were adapted from several maps made by the state geological surveys of Ohio, Pennsylvania and West Virginia. The narrow areas occupied by rocks of the Monongahela group in the valley of the Ohio River, in the valleys of many of the streams traversing the Dunkard area in eastern Ohio, and in the lower reaches of a number of the larger streams in western West Virginia are not indicated. In addition to the principal region occupied by the Dunkard series, as shown on the map, there are outliers of small areal extent in Ohio, West Virginia, Pennsylvania and Maryland. The most remote of these outliers from the main body of the Dunkard series deposits are near the town of Frostburg in Allegany County, Maryland.

The Greene group occupies the central part of the principal area of Dunkard series as delimited on the map. In traveling in any direction from the central portion of the area, one encounters progressively older strata from the Greene group to the Washington, the Monongahela and the Conemaugh. This progression from younger strata in the central part of the area to older strata toward the sides is indicative of the geosynclinal structure they occupy. This region includes the lowest portion of the Appalachian geosyncline, the axis of which trends in a general northeast-southwest direction from southwestern Pennsylvania across western West Virginia and into eastern Kentucky. The deepest portion of this elongate structural basin, according to Hennen (1909: 65-66), is probably in Wetzel County, West Virginia in the Nineveh syncline. Besides the Nineveh syncline there are a number of other synclines and anticlines within the Appalachian geosyncline which have been fully described and mapped by the geological surveys of the states in which they are found.

Another major structure of interest within the area is the Burning Springs anticline with its axis cutting almost north-south across Washington County, of Ohio and Pleasants, Wood, Ritchie, Wirt and Calhoun counties of West Virginia. This anticline, crossing the Appalachian geosyncline, elevates the strata to such an extent that a narrow belt of Allegheny, Conemaugh and Monongahela groups (six miles wide in the north to about one mile in the south) outcrops across parts of the counties named above.

General stratigraphic sections are included in the portion of this paper relating to new localities.

PREVIOUS WORK

Although no extensive prospecting for fossil vertebrates in this region was undertaken by any institution before the Carnegie Museum's field party, there had been a number of discoveries of tetrapod fossils made by various individuals. Those earlier localities, exclusive of places where footprints or only coprolites were found, are briefly mentioned below. The approximate geographic location of each previously discovered locality is indicated by a white letter within a small black square on the map accompanying this report. The same letters are used to designate the approximate stratigraphic positions of the fossiliferous strata of the respective localities on geologic sections given under the heading "New Localities." No geologic section is given for the Allegheny group since no new localities were found within its strata.

The earlier localities are listed immediately below in ascending stratigraphic order, the lowest being given first, etc. The works cited in localities A and B are not intended to represent complete bibliographies for the descriptions of fossils from those places.

PENNSYLVANIAN SYSTEM

PITTSBURGH SERIES

Allegheny Group

Locality A

The oldest locality in this region is at Cannelton, Beaver County, Pennsylvania. Besides fishes, a few amphibians were found here in the shale forming the roof of the Middle Kittanning coal, near the middle of the Allegheny group. Descriptions of some of the fossils found here were made by Moodie (1909) who also briefly reviewed the locality in a later paper (1916: 15-16).

Locality B

The well known Linton, Jefferson County, Ohio locality produced many fossil forms, most of the tetrapods being amphibians. Early notice of the amphibians found here was made by Jefferies Wyman (1856: 172-173), and he later described several of the specimens (1858: 158-163). Later, both Cope and Moodie, in numerous papers, described the forms from this locality. Recently, both M. Steen (1930: 849-981) and A. S. Romer (1930: 77-147) have restudied the Linton fauna. The

Linton cannel coal, at the Upper Freeport horizon at the top of the Allegheny group, was the fossiliferous bed.

Conemaugh Group

Locality C

The lowest tetrapod horizon in this group was found by P. E. Raymond (1907: 835) at Pitcairn, Allegheny County, Pennsylvania. E. C. Case (1908: 234-241) first described the fossils which are restudied by Dr. Romer in his accompanying paper. The fossils came from near the middle of the Conemaugh group, about 315 feet below the base of the Pittsburgh coal. The fossiliferous stratum is the Pittsburgh red shale, called the Round Knob horizon in Ohio (see Condit, 1912: 35-37).

Locality D

A locality near Jewett in Harrison County, Ohio, was mentioned by Condit (1912: 39, 283). Here, what was thought to be a limb bone of a reptile was found in the Ewing limestone. This bone was not further described and was later lost (see Case, 1915: 84). The Ewing limestone is not indicated on the general section of the Conemaugh group given on a following page of the present paper, but in some places in Pennsylvania as well as in West Virginia and Ohio it does occur near the middle of the Pittsburgh red shale (see I. C. White, 1891: 92 and Johnson, 1929: 65). The possibility that this Ewing limestone vertebrate horizon corresponds to that of the Pitcairn, Pennsylvania locality (Locality C of this report) was mentioned by Condit (1912: 283).

In addition to the Jewett, Ohio locality, Condit (1912: 28) stated that reptilian fossils were present in the Birmingham shale but he did not give the locations of any such occurrences. Case (1915: 84) mentioned that these fossils were lost before he had seen them. This occurrence of vertebrates is not indicated on the map or geologic sections of this paper.

Locality E

Near Saltlick Bridge P. O., Braxton County, West Virginia, was found what appeared to be the cast of a fossil bone at a point about 200 feet below the Pittsburgh coal and not far above the Ames limestone.

This cast was the subject of a paper by Case (1917: 817-821), but to quote from White (1917: 822) “. . . he (Case) did not think best to give it a name until other portions of the skeleton had been found.”

In White's paper just mentioned, he himself gave the specimen the name *Pareiasaurus* (?) *henni*. In regard to the application of a name to this specimen, Romer (1935: 1635) said, "This is unfortunate, for the specimen certainly does not pertain to *Pareiasaurus* (definitely confined to the upper Permian), and is doubtfully a fossil at all."

Locality F

The Montrose, Allegheny County, Pennsylvania locality, discovered by W. C. Darrah, was stratigraphically the highest to have been found in the Conemaugh group previous to 1934. The fossil amphibian at this place came from a carbonaceous shale at the Clarksburg horizon. The Clarksburg horizon is in the upper part of the Conemaugh group, about 100 feet below the Pittsburgh coal.

Monongahela Group

No tetrapods had been reported from this group previous to the one locality (locality no. 3) which the Carnegie field party found.

PERMIAN SYSTEM

DUNKARD SERIES

Washington Group

Locality G

At Oglebay Park, near Wheeling, in Ohio County, West Virginia, John L. Tilton (1930: 111) found a portion of a spine of *Edaphosaurus* sp. This fossil was found in the basal portion of the Elm Grove limestone, from 5 to 15 feet above the roof of the Waynesburg coal, and is stratigraphically the lowest to have been reported within the Washington group.

Locality H

Clinton R. Stauffer found a partial spine of *Edaphosaurus* sp. at Marietta, Washington County, Ohio (Stauffer, 1916: 88) (Stauffer and Schroyer, 1920: 147). The fossil-bearing bed was the Creston Reds, near the horizon of the Washington "A" coal. Since there are some differences in opinion as to the exact limits of the Creston Reds, the position of this locality on the geologic column of the Washington group for West Virginia on a following page of the present paper is only approximate.

Locality I

The locality at Portland, Jackson County, West Virginia, found by G. Carder and described jointly by R. W. Whipple and E. C. Case

(1930: 370-372), yielded fossils from the lower part of the Upper Marietta sandstone. The specimens from this place were identified by Case as parts of *Edaphosaurus cruciger* Cope.

Greene Group

Locality J

Three miles east of New Martinsville, in Wetzel County, West Virginia, J. L. Tilton (1926: 391-394) found tetrapods in the Nineveh limestone. The fossils found here were identified by Case (see Tilton, 1926: 392), as “. . . a collection of the intercentra of a rachitomous stegocephalian . . .”

Locality K

A few miles southeast of Rockport, Wood County, West Virginia, one caudal vertebra, not identified, is reported by Tilton (1926: 393). The horizon of the fossil-bearing bed is Lower Rockport limestone. The position of this locality on the map accompanying the present paper is uncertain.

Locality L

At Limestone Hill, Wirt County, West Virginia, vertebrates were found at the Upper Rockport limestone horizon. Whipple and Case (1930: 371) gave a preliminary list of the following tetrapod forms represented at this locality, including *Lysorophus*, *Theropleura*, *Dimetrodon* and *Trimerorachis*.

Locality M

The fossil found one-half mile east of McKinley Central Church, Wood County, West Virginia, is apparently stratigraphically the highest to have been found previous to 1935. Tilton (1926: 393) reported that the fossil, an intercentrum of the *Trimerorachis* type, came from the Gilmore limestone. The position of this locality on the map accompanying the present paper is uncertain.

Locality N

About five miles southwest of Cottageville, Jackson County, West Virginia, were found portions of the skeleton of a cotylosaur described by Dr. Romer in his accompanying paper. This specimen at the United States National Museum under Catalog No. 12166 was apparently found in a sandstone. The stratigraphic position of the fossiliferous stratum is not known, nor is the geographic position on the map

accompanying this paper certain. This occurrence is not indicated on any geologic column in this paper.

NEW LOCALITIES

This portion of this report consists of the stratigraphic and geographic descriptions of each locality at which collections were made by the Carnegie Museum field parties. Brief descriptive information concerning the geology of the area and several stratigraphic sections are included.

The Carnegie Museum localities are described on the following pages in ascending stratigraphic order, those in the Conemaugh group first, followed by the locality in the Monongahela group, etc. Each locality is designated by a number which has been assigned as nearly as possible in ascending stratigraphic order; that is, locality 1 being stratigraphically lower than locality 2, and 2 stratigraphically below locality 3, etc. These numbers are shown on most of the geologic sections in this paper to indicate the approximate stratigraphic positions of the fossiliferous beds of the localities they represent.

On the map accompanying this report the locality numbers appear in white on small black squares and indicate the general geographic positions of each fossil locality.

PENNSYLVANIAN SYSTEM

PITTSBURGH SERIES

Conemaugh Group

This group extends from the top of the Freeport coal up to the base of the Pittsburgh coal and is, according to Leighton (1939: 11), 600 to 630 feet thick at Pittsburgh, Pennsylvania. The coals are thin. Sandstones, shales and limestones make up the principal beds. Both fresh-water and marine limestones are present, and of the latter, Leighton (1939: 11) said, "These are more persistent than the shales, sandstones, or fresh-water limestones and are excellent key beds. A generalized section of the Conemaugh group is difficult to construct because of the great variations in most of its members."

Leighton's generalized section (1939: 11-12) is reproduced below, with additions by the writer parenthesized. The approximate stratigraphic positions of new localities in Pennsylvania and of previous localities in Ohio, Pennsylvania and West Virginia are indicated at the right of the section.

Section of the Conemaugh Group for Pennsylvania

	<i>Feet</i>	<i>Previous Localities</i>	<i>New Localities</i>
Shale and thin fresh-water limestones	35		
Shales	30		1, 2
Shales and thin fresh-water limestones	21		
Connellsville sandstone	15		
Shale	5		
Clarksburg coal	1/2	F	
Clarksburg limestone	3		
Clarksburg clay	8		
Vari-colored clays and shales	45		
Morgantown sandstone	33		
Wellersburg coal	1/2		
Wellersburg clay with nodular limestone	21		
Birmingham shale	30		
Duquesne coal	1		
Duquesne clay	9		
Grafton sandstone	2	E (?)	
Colored clays or shales	15		
Ames limestone, marine	3		
Harlem coal	1/2		
Pittsburgh red beds—clays	30	C, D	
Upper Saltsburg sandstone	30		
Bakerstown coal	1		
Bakerstown fresh-water limestone and clay	10		
Lower Saltsburg sandstone	20		
Woods Run limestone	1		
Woods Run coal	1/2		
Shales and clays	10		
Lower Woods Run limestone	1/2		
Shales	35		
Pine Creek or Cambridge limestone	2		
Buffalo sandstone	25		
Shales	30		
Brush Creek limestone, marine	1		
Shales	10		
Brush Creek coal	1		
Shales	10		
Upper Mahoning sandstone	27		
Mahoning coal, clay, limestone	15		
Lower Mahoning sandstone	25		

Locality 1: City of Pittsburgh, Allegheny County, Pennsylvania

Less than two miles from Carnegie Museum, a number of fossils were collected in an abandoned quarry. This quarry was located on the east side of Soho Street, two to three tenths of a mile north of Fifth Avenue. Several years after the collection was made, the quarry was completely covered under the fill for a large housing project. The elevation of the fossiliferous limestone is about 1,040 feet above sea level.

The fresh-water limestone which carries the fossils is two feet thick and has a thin shaly parting in the middle. The limestone is light

gray on fracture, but weathered surfaces are generally stained yellow and brown. Besides bone fragments many ostracods and worm tubes stand out on weathered pieces of the matrix.

By hand-level measurement this limestone was found to lie 40 feet beneath the base of the Pittsburgh coal and therefore can be considered to be a bed of the Pittsburgh limestone. The term "Pittsburgh limestone" is employed in this paper, as it has at times been used by the Pennsylvania Geological Survey (Johnson, 1929: 43); i. e., to identify those limestone beds which at times occupy positions between the base of the Pittsburgh coal and a point 70 feet beneath that coal. As thus defined, the Pittsburgh limestone includes within its limits the Lower Pittsburgh limestone of F. and W. G. Platt and others.

Locality 2: Collier Township, Allegheny County, Pennsylvania

In an abandoned quarry between Walkers Mills and Ewingsville, Pennsylvania, a few fragmentary fossils were collected in 1934. The quarry is about 250 feet northeast of the first railroad bridge over Robinson Run, along the tracks of the P. C. C. and St. L. railroad line going east from Walkers Mills. Approximate elevation of the quarry is 860 to 880 feet above sea level.

The fossils were found in a fresh-water limestone, 18 inches thick, which outcropped near the top of the quarry. This limestone is quite carbonaceous and is dark gray on a freshly fractured surface but weathers light brown to light gray. It lies immediately beneath a coal, one foot thick, and about 16 inches beneath a massive limestone, five feet thick. The coal one foot thick, immediately overlying the fossil-bearing bed, is apparently the Little Pittsburgh coal.

The limestone containing fossils was found by hand-level measurement to lie 25 feet beneath an outcrop of the Pittsburgh coal and may be considered to be a bed of the Pittsburgh limestone.

Monongahela Group

This group, with the Pittsburgh coal as its basal member and the Waynesburg coal as its uppermost member, yielded tetrapod fossils at but one place in this area, and no previous localities have been noted. The Monongahela group is conspicuous for the large number of fresh-water limestones included in its measures, so it is surprising that no other fossil tetrapod localities were found within its strata.

In Tyler County, West Virginia, the only place at which fossils were collected in this group, David B. Reger (1929: 139) gives a thickness of

300 feet for the Monongahela group. The general section given by him (1929: 140) is reproduced below omitting, however, the total feet and intervals included in his original section. The word "group" in the title below has been substituted for the word "series" which was used by Reger. At the right of the section the stratigraphic position of the locality is indicated by its number.

General Section of the Monongahela Group for West Virginia

	<i>Feet</i>	<i>Previous Localities</i>	<i>New Localities</i>
		None	
Coal, Waynesburg.....	5		
Shale, gray or red.....	10		
Sandstone, Gilboy, gray or green.....	35		
Coal, Little Waynesburg.....	1		
Limestone, Waynesburg, gray.....	4		
Shale, gray or red.....	13		
Sandstone, Uniontown, gray or green.....	35		
Shale, Annabelle, brown 15 ft. to.....	0		
Coal, Uniontown.....	2		
Shale, gray or red.....	10		
Limestone, Uniontown, gray or red.....	15		3
Shale, red or green, with thin sandstones and limestones	44		
Sandstone, Arnoldsburg, gray or green.....	30		
Coal, Lower Uniontown.....	1		
Limestone, Arnoldsburg, 7 ft. to.....	0		
Shale, Fulton Green.....	5		
Limestone, Benwood, gray.....	65		
Sandstone, Sewickley, gray.....	25		
Coal, Sewickley.....	5		
Sandstone, Lower Sewickley, gray.....	25		
Coal, Lower Sewickley, 2 ft. to.....	0		
Limestone, Sewickley, gray or yellow.....	43		
Sandstone, Cedarville, gray or green, 40 ft. to.....	0		
Coal, Redstone.....	4		
Sandstone, Weston, gray or green, 20 ft. to.....	0		
Limestone, Redstone, yellow.....	5		
Sandstone, Upper Pittsburgh, gray.....	15		
Shale, Weston, gray.....	5		
Coal, Pittsburgh.....	8		

Locality 3, Lincoln District, Tyler County, West Virginia

Fossils were found in an outcrop just north of Owl Run, one and one-half miles northeast of Sistersville, West Virginia, at the west side of the road (West Virginia Route 2) to Paden City. The approximate elevation of the outcrop is 650 feet above sea level.

The fossils were found in a bed of light gray limestone about one foot thick. The fossil-bearing bed is overlain by four feet of red shale over which is a one foot limestone, and beneath the fossil bed are two

to three feet of red shale under which is a nodular limestone two feet thick.

The "Sistersville Section" made by Hennen (1909: 120-121), taken about three-fourths of a mile above Sistersville, was used in determining the stratigraphic position of the fossil-bearing bed. The fossiliferous limestone is about 25 feet below what appears to be the coal identified as the Uniontown in Hennen's "Sistersville Section."

The fossil-bearing stratum at this locality is the second limestone below the Uniontown coal and is one of a series of thin beds of limestone, which at this place appear to represent the Uniontown limestone.

PERMIAN SYSTEM
DUNKARD SERIES
Washington Group

This group, the lower of the two groups in the Dunkard series, includes the strata from the top of the Waynesburg coal up to the top of the Upper Washington limestone. The thickness of the group is generally considered to vary from 250 feet to about 400 feet. The nature of the strata of the Washington group is shown in the sections given on the following pages.

The published geologic sections of both groups of the Dunkard series for Pennsylvania differ in many respects from those sections for West Virginia. A great many of the differences are no doubt due to variation of individual beds as they are found within the two states, but in addition there were, in the past, different names given in each state to the same individual stratum. In several cases the same name was used by geologists of both Pennsylvania and West Virginia in reference to different lithologic units. This condition could be rectified only by considerable field work and would require making many sections and visiting numerous type localities. No such ambitious task has been undertaken by the writer, but a statement was considered necessary to explain the employment and differences in the geologic sections for Pennsylvania and for West Virginia in both groups of the Dunkard series in this paper.

Some of the differences in the named stratigraphic units of the Washington group in West Virginia and in Pennsylvania may be seen in the two sections which are given on the following pages. Unfortunately, the Pennsylvania section does not include the less prominent and unnamed shales, limestones and sandstones and so does not

depict the true stratigraphic conditions as well as does the West Virginia section.

The positions of both the new and previous localities that were found in this group are indicated only on the geologic section of the state in which they were found. The only exceptions are that both new locality 6 and previous locality H, which are in Ohio, are shown on the West Virginia section, because no section for Ohio is included with this report.

The following section is taken from a general section of the Dunkard series for West Virginia which was given by Ray V. Hennen and David B. Reger (1913: 165-166). The lower part of their section is reproduced here, omitting only a series of figures of total feet which they gave in the original. The names in parenthesis, to quote Hennen and Reger (1913: 166) “. . . have all been added by the writer and others since the publication of the original Dunkard Creek section by I. C. White on page 22 of Bulletin 65 of the U. S. Geological Survey in 1891.”

*General Section of the Washington Group
Dunkard Series, for West Virginia*

	<i>Feet</i>	<i>Previous Localities</i>	<i>New Localities</i>
Limestone, Upper Washington.....	4		
Shale, limy.....	5		
Sandstone, (Hundred).....	34		
Coal, (Hundred) (5 in.) to.....	1		
Fire clay and red and variegated shale.....	34		
Sandstone, (Upper Marietta).....	50	I	9
Coal, Washington "A".....	1		
Shale, red, (Creston).....	60	H	
Limestone, Middle Washington.....	5		
Sandstone, (Lower Marietta).....	40		
Limestone, Lower Washington.....	2		
Coal, Washington.....	3		
Fire clay shale, (Washington).....	10		
Limestone, (Bristol).....	2		
Sandstone, Washington.....	10		
Coal, Little Washington.....	1		
Shale	7		7?
Sandstone, (Mannington) (Waynesburg "B" coal. horizon near middle).....	45		
Shale	4		
Coal, Waynesburg "A".....	1		
Fire clay and shale.....	3		
Limestone, Mt. Morris.....	2		6
Shale	12		
Sandstone, coarse, brown and pebbly, Waynesburg	45		5
Limestone, dark flaggy, (Elm Grove).....	3	G	4
Shale, dark, sandy with fossil plants, Cassville.....	5		
Coal, Waynesburg			

Variation within both the Washington and Greene groups in Pennsylvania made unsuitable any one general section hitherto published for those groups as seen in Pennsylvania, so the writer, using several publications, compiled composite sections of the principal geologic units for those two groups of the Dunkard series. Therefore, the section of the Washington group, given below, and of the Greene group for Pennsylvania, given on a following page, indicate the relative positions of the strata and show the irregularities in thickness as found in Pennsylvania but do not give a true section for any one place. The intervals between the named beds are not shown and vary in composition from place to place, but are generally shales and thin sandstones.

*General Section of the Washington Group,
Dunkard Series, for Pennsylvania*

	<i>Feet</i>	<i>Previous Localities</i>	<i>New Localities</i>
		None	
Upper Washington limestone.....	4-15		11
*Brier Hill sandstone.....	0-20		
Jollytown limestone (of R. W. Stone).....	1- 5		10
Jollytown coal (of J. J. Stevenson) 5 in. to 20 in.			
Jollytown sandstone (of d'Invilliers).....	?-40		
Middle Washington limestone.....	3-25		
*Upper Marietta sandstone.....	0-75?		
Washington "A" coal.....	0- 5		
*Middle Marietta sandstone.....	0-40?		
Blacksville limestone.....	3- 5		
*Lower Marietta sandstone.....	0-40?		
*Washington Rider coal.....	0- 1		
Lower Washington limestone.....	0-20		8
Washington coal.....	3-10		
Washington sandstone.....	5-25		
Little Washington coal.....	0- 1		
Taylortown limestone.....	0-20		
*Upper Mannington sandstone.....	0-20		
Waynesburg "B" coal.....	0- 2		
*Lower Mannington sandstone	0-30		
Colvin's Run limestone.....	0-10		
Waynesburg "A" coal.....	0- 4		
Mount Morris limestone.....	1- 5		
Waynesburg sandstone.....	10-70		
*Elm Grove limestone.....	0- 1		
Cassville shale.....	0-15		

Those beds which are starred have been included in this column after their use by Hickok and Moyer (1940: 145-152) in the Pennsylvania Geological Survey volume on Fayette County, Pennsylvania. These same starred beds were included here in this paper only after checking through various older reports on Washington and Greene

counties and finding that beds, stratigraphically and lithologically similar to them (as represented by Hickok and Moyer), had been previously noted to occur at places in Washington or Greene counties of Pennsylvania.

Comparison of the section of the Washington group for West Virginia with that for Pennsylvania, just given, shows numerous differences in the two sections. Some of the differences are due to mis-identification of strata and to the duplication of names applied to different stratigraphic units. One such instance, which concerns the stratigraphy of some of the fossil localities in this paper, is in those beds which are named the Jollytown coal, Jollytown limestone and the Jollytown sandstone. The history of those terms and their uses are briefly mentioned here.

The term "Jollytown coal" was first used by John J. Stevenson (1876: 48) as the name for a thin bed of coal which was found to occur from 20 to 75 feet *below* the Upper Washington limestone in Greene and Washington counties in Pennsylvania. That term has since been used in publications of the U. S. Geological Survey and Pennsylvania Geological Survey in that same sense, and is so shown on the general section of the Washington group, Dunkard series, for Pennsylvania in this paper. In publications of the West Virginia Geological Survey the name "Jollytown coal" is applied to a coal just *above* the Upper Washington limestone after the usage of I. C. White (1891: 34). Since the top of the Upper Washington limestone marks the upper limit of the Washington group of the Dunkard series, the Jollytown coal of White is in the Greene group. In the general section of the Greene group of the Dunkard series for West Virginia in this paper, White's interpretation is used.

The name "Jollytown limestone" was first used by I. C. White (1891: 34) in reference to a limestone, one to ten feet thick, occurring 25 to 30 feet below the Dunkard coal and above the Jollytown coal of White (1891: 34), which *overlies* the Upper Washington limestone. The term "Jollytown limestone" is used in this sense by the West Virginia Geological Survey and is so shown on the general section of the Greene group of the Dunkard series for West Virginia in this paper. In Pennsylvania, R. W. Stone (1905: 6) applied the name "Jollytown limestone" to a bed of limestone five feet or less thick, which occurred 30 feet above the "Jollytown coal" of Stevenson (1876: 48) and 20 feet *below* the Upper Washington limestone. This "Jollytown limestone"

of R. W. Stone is apparently Limestone V of Stevenson (1876: 48), which Stevenson later named the Franklin limestone (1907: 102). In reports of the U. S. Geological Survey and of the Pennsylvania Geological Survey since 1905, R. W. Stone's usage of "Jollytown limestone" has been followed. In the general section of the Washington group, Dunkard series, for Pennsylvania, the Jollytown limestone is shown in the position it should occupy according to Stone's definition.

The term "Jollytown sandstone" was first applied by E. V. d'Invilliers (1895: 2573) to "a massive sand deposit, or irregular structure, weathering into fantastic forms, appearing at many localities and helping the geologist to identify the Jollytown coal bed above it." The Jollytown coal bed he refers to is Stevenson's occurring *below* the Upper Washington limestone. The name "Jollytown sandstone" in this sense has not since been used as far as the writer could determine, but is indicated on the general section of the Washington group, Dunkard series, for Pennsylvania in this paper. Apparently, the Pennsylvania Geological Survey did not use the term "Jollytown sandstone" at all after it had been given by d'Invilliers. Recently, W. O. Hickok IV and F. T. Moyer (1940: 151) have given the name "Davistown sandstone" to a sandstone which is from 10 to 30 feet thick and medium to heavy bedded and which occurs beneath the Jollytown coal (of Stevenson) and above the Middle Washington limestone. This bed is found in Fayette County, Pennsylvania, to the east of Washington and Greene counties. Since the Davistown sandstone appears to occupy a stratigraphic position similar to that of the "Jollytown sandstone" of d'Invilliers, the possibility of their representing the same lithologic unit is suggested. In West Virginia, R. V. Hennen (1909: 196-197) gave the name "Jollytown sandstone" to a massive sandstone, five to 30 feet thick, found from five to 10 feet above the Jollytown coal (of White). The term "Jollytown sandstone," according to Hennen's definition, has been followed by the West Virginia Geological Survey. It is indicated in the general section of the Greene group, Dunkard series, for West Virginia in the present paper according to Hennen's definition.

Locality 4.—Sand Hill District, Marshall County, West Virginia

The fossils at this locality were found in an outcrop of limestone in the bed of a creek, known locally as Line Run. This creek is not named on maps but is the first stream to enter Wheeling Creek from the north, east of the town of Viola, West Virginia. The outcrop is about 60 feet northeast of an old church which is one and three-tenths

miles southeast of Viola. The approximate elevation of the fossiliferous limestone is 820 feet above sea level.

Fossils were found in one of several thin limestone beds which are gray and light brown in color and which make up a limestone horizon several feet in thickness. There is a sandstone horizon above these thin limestones.

From the Map of General and Economic Geology (Hennen, 1909) which indicates the outcrop of the Waynesburg coal, it appears that the fossil-bearing beds are not more than 20 feet above the Waynesburg coal. Apparently, the fossiliferous stratum is the Elm Grove limestone, which according to Hennen (1909: 247) is one to five feet thick and is five to ten feet above the Waynesburg coal in this area.

Locality 5.—McClellan District, Doddridge County, West Virginia

At a roadside sandstone quarry near the town of Centerpoint, West Virginia, a few fragmentary fossil bones were collected. The quarry is about 200 feet east of a bench mark (elevation 790 feet) which is located at the junction of the road which runs (east) up Pike Fork, with the road running in north-south direction through Centerpoint. The approximate elevation of the fossiliferous sandstone is 800 feet above sea level.

The sandstone is greenish gray in color and had a thickness of 20 feet or more. The fossils were found in blocks already broken from the quarry face, so it is not known from what part of the stratum they came.

In answer to the writer's request for advice in regard to this locality, Mr. John P. Nolting, Jr., Assistant Geologist of the West Virginia Geological and Economic Survey, very kindly suggested that the fossiliferous sandstone is more likely the Waynesburg sandstone than the Mannington. From the structure as indicated by Hennen (1912) on the Map of General and Economic Geology and with the intervals between the Washington and Waynesburg "A" coals also given by Hennen (1912: 172), it appears that the Waynesburg sandstone is the correct identification of the bed which at this place contained fossils.

Locality 6.—Adams Township, Monroe County, Ohio

The fossil-bearing outcrop of this locality is in the southwest quarter of Section 18, Township 3 North, Range 4 West. The strata containing fossils outcrop on the east bank of Herds Run (not named on maps), one and three-tenths miles southwest of the bridge over Sunfish Creek, at Cameron, Ohio. There is a U. S. Coast and Geodetic Survey pre-

liminary elevation marker number U66/1934 (preliminary elevation 877.6 feet) set in the face of a sandstone cliff, about 60 feet southwest, across the road (Cameron-Woodfield Road, Ohio State Route No. 78) from the outcrop. The approximate elevation of the fossiliferous outcrop is 862 feet above sea level.

Fossils were found in two layers of limestone each eight inches thick, in five inches of gray shale between the two limestones, and in the upper two feet of a gray shale bed which is eight feet thick and which immediately underlies the limestones mentioned above. The strata containing fossils vary in total thickness from two feet, four inches to three feet, nine inches.

The fossiliferous beds were found to lie from seven to ten feet beneath a coal, one foot thick. This coal, at an elevation of about 870 feet, has been identified as the Waynesburg "A" coal by Wilbur Stout, the State Geologist of Ohio, who has very kindly sent me a section which he had made at this place. In that section he identified the massive sandstone about 40 feet thick, unconformably overlying the Waynesburg "A" coal, as the Washington sandstone. With the aid of Wilbur Stout's section, the stratigraphic positions of the fossiliferous strata were found to be from seven to ten feet beneath the Waynesburg "A" coal. This stratigraphic position is at the horizon occupied by the Mount Morris limestone in West Virginia and Pennsylvania.

Locality 7.—Sand Hill District, Marshall County, West Virginia

The northernmost locality in West Virginia at which the Carnegie Field Party collected is about one and one-half miles southeast of Viola, West Virginia. The fossils were found in the limestone which forms the second waterfall as one goes (north) up Ruth Hollow from Wheeling Creek. Ruth Hollow is the valley of the second stream to enter Wheeling Creek from the north, east of the town of Viola, West Virginia. Neither Ruth Hollow nor the stream flowing in it are named on maps. The elevation of fossil outcrop is not known.

The fossiliferous fresh-water limestone is very dense and is gray on a fresh surface, but weathers to a yellowish gray. The thickness is not known.

Since no other information about this locality is available at present, the stratigraphic position of the fossil-bearing bed has not been determined. From Hennen's (1909) Map of General and Economic Geology of this area, it appears that the limestone in question lies between the Waynesburg and Washington coals, within the Washington group.

Locality 8.—Richhill Township, Greene County, Pennsylvania

A limestone outcropping along the ditch on the west side of Pennsylvania State Route No. 21 between Ryerson Station and Wind Ridge P. O., Pennsylvania, was found to contain vertebrate fossils. This point of outcrop is nine-tenths of a mile northeast of the bridge over the North Fork of Dunkard Fork at Ryerson Station, and has an approximate elevation of 1,060 feet above sea level.

The individual bed of limestone containing the fossils is dark gray, weathers to a light gray color, and has a thickness of two feet.

The fossiliferous limestone is in the lower part of the Lower Washington limestone. At this place, the Lower Washington limestone is ten feet thick, being made up of five or more beds of limestone each of which vary in thickness from three inches to two feet. The Washington coal, two to three feet thick, outcrops here just two feet beneath the base of the Lower Washington limestone.

Locality 9.—Clay District, Monongalia County, West Virginia

This locality is a road cut on the east side of the Blacksville-Hundred Road (West Virginia Route No. 7) about one and one-half miles west of Blacksville, West Virginia. The fossiliferous stratum is exposed about 100 yards northeast of the confluence of Miracle Run and Dunkard Creek. The approximate elevation of the fossil-bearing bed is 995 feet above sea level.

Fossils were found in a siliceous limestone lens about 15 feet in length which had a maximum thickness of six inches.

The stratigraphic position of the fossiliferous lens is not certain, but appears to be about 40 feet beneath the Hundred sandstone at the stratigraphic horizon of the Upper Marietta sandstone.

Locality 10.—Richhill Township, Greene County, Pennsylvania

At this locality fossils were found in an outcrop on the east side of the McCracken-Ryerson Station, Pennsylvania Road, two-tenths of a mile north of McCracken. The approximate elevation of the outcrop is 1,010 feet above sea level.

The stratum containing fossils is a brown, sandy shale. This shale lies two to six inches beneath a limestone five feet thick.

From the position of the Upper Washington limestone, as indicated on the Map of Areal Geology in the Rogersville Folio (Frederick G. Clapp, 1907) and from the intervals given there from that bed to the Jollytown limestone, it appears that the limestone immediately over-

lying the fossiliferous shale is the Jollytown limestone of R. W. Stone (see explanation of Jollytown limestone given on a previous page of this paper).

Locality 11.—West Finley Township, Washington County, Pennsylvania

At this locality fossils were found in an old limestone quarry about three and three-fourths miles southeast of West Alexander, Pennsylvania, on the road leading to West Finley. The quarry is on the east side of the road, eight-tenths of a mile southeast of Kimmins school-house. The approximate elevation of the quarry is 1,120 feet above sea level.

The fossils came from a layer which is 10 inches thick and is separated from the carbonaceous shale (containing plant fragments) above it by just three and one-half inches of shaly limestone. The base of the fossil-bearing bed is seven feet, nine inches below the top of the quarry (this measurement includes residual soil at the top). The fossil layer is a hard and compact, dark gray limestone on a fresh surface, but the weathered rock is best described as rotten, almost clayey, and brown in color.

The limestone in this quarry is the Upper Washington limestone at the top of the Washington group. It was identified by its thickness (here about nine and one-half feet) and the characteristic carbonaceous shale containing plant fragments, immediately overlying it. In addition a coal one foot, eight inches thick, which appears to be the Jollytown coal (of Stevenson), was observed in the east bank of the road, at a point three-tenths of a mile north of the quarry, giving an interval of 40 to 50 feet from the Jollytown coal up to the Upper Washington limestone.

Greene Group

All the Paleozoic strata in this region occurring above the top of the Upper Washington limestone are included in the Greene group of the Dunkard series. The thickness of the rocks so included is about 800 feet (J. J. Stevenson, 1876: 35) in extreme southwestern Pennsylvania and in parts of northwestern West Virginia. Erosion has reduced the thickness to varying degrees in the other regions covered by this group of strata, the maximum in Ohio being about 250 feet according to C. R. Stauffer and C. R. Schroyer (1920: 21).

The two sections given below illustrate differences in the named stratigraphic units in West Virginia and in Pennsylvania. The first is a section which was given by Hennen and Reger (1913: 165-166). Only

the upper part of their section is given here, the lower part having been given on a previous page of this paper. A series of figures of total feet given in the original section is omitted here. Additions or alterations made to their section by the present writer are enclosed in brackets, and to quote Hennen and Reger (1913: 166) in reference to this section, "The names in parenthesis—25 in number—have all been added by the writer and others since the publication of the original Dunkard Creek section by I. C. White on page 22 of Bulletin 65 of the U. S. G. Survey in 1891."

*General Section of the Greene Group
Dunkard Series, for West Virginia*

	<i>Feet</i>	<i>Previous Localities</i>	<i>New Localities</i>
Sandstone, flaggy (Upper Proctor).....	40		
Shale	15		
Sandstone, (Middle Proctor).....	25		
Shale	10		
Sandstone, massive, green, micaceous.....	25		
(Lower Proctor)			
Shale, red and variegated.....	35		
Limestone, Windy Gap.....	5		
Sandstone, massive, (St. Cloud).....	20		
Shale, sandy.....	4		
Coal, slaty, Windy Gap, 3" to.....	1		
Fire clay, shale, red, and variegated, with layers of limestones and sandstones.....	80		{33, 34, 35? 36? 37?
Sandstone, massive, Gilmore.....	30		
Coal (Gilmore).....	1		
Limestone (Gilmore)	1	M	32?
Shale, variegated and red, with thin sandstones...	93		
Limestone, Upper (Rockport).....	5	L	29? 30? 31
Sandstone, (Taylor)	30		
Limestone, Middle (Rockport).....	5		{25? 26? 27? 28?
Sandstone, and shale, buff and red.....	29		
Coal, (Nineveh "A") 3" to.....	1		
Limestone, (Lower Rockport).....	5	K	{18? 20? 21? 22 23
Shale, brown and variegated.....	15		
Sandstone, massive, coarse and brown, Nineveh....	25		
Shale, 1' to.....	4		
Coal, Nineveh	1		
Fire clay and limy shale.....	10		
Limestone, Nineveh	5	J	16, 17? 19?
Shale, variegated and red.....	30		
Sandstone, massive, (Burton).....	29		
Coal, Hostetter.....	1		
Shale, sandy, with thin sandstones.....	60		
Sandstone, massive, (Fish Creek).....	34		
Coal, (Fish Creek).....	1		13? 14?
Fire clay shale (Fish Creek).....	5		
Shale, sandy and red, with thin sandstones.....	29		

	<i>Feet</i>	<i>Previous Localities</i>	<i>New Localities</i>
Sandstone, massive (Rush Run).....	25		
Shale, sandy.....	5		
Coal, Dunkard.....	1		
Fire clay and shale, red, sandy and variegated....	29		
Sandstone, (Jollytown) [of R. V. Hennen].....	20		12?
[Limestone, Jollytown of I. C. White.....	1]		
Coal, Jollytown [of I. C. White].....	1		
Fire clay.....	1		

The section given below is a compilation of the principal geologic units taken from several publications and does not give an accurate section for any one place. Intervals, generally of thin sandstones and shales, occurring between named units are not shown.

*General Section of the Greene Group
Dunkard Series, for Pennsylvania*

	<i>Feet</i>	<i>Previous Localities (None)</i>	<i>New Localities</i>
Proctor sandstone and concealed.....	40-115		
Windy Gap limestone.....	4- 5		
Windy Gap coal.....inches to.....	1		
Gilmore sandstone.....	25- 40		
Gilmore coal.....less than.....	1		24?
Nineveh sandstone.....	15- 30		
Nineveh coal.....inches to.....	1		
Nineveh limestone.....	4- 10		15
Hostetter coal.....1" to15".....			
Claysville limestone (position not certain).....	6- 8		
Fish Creek sandstone.....	10- 60		
Dunkard coal (Fish Creek coal).....	1- 2		
Prosperity limestone.....	10- 20		
Ten Mile (Sparta) coal.....	0- 3		
Donley limestone.....	5- 8		
*Dunlap sandstone.....	?- 31		
Upper Washington coal.....	0- 1		

* The Dunlap sandstone was recently described by Hickok and Moyer (1940: 152-153) from its occurrence in Fayette County, Pennsylvania. As mentioned by them, J. J. Stevenson had noted (1876: 35-36), but did not name, a sandstone at the same stratigraphic horizon in Washington County, Pennsylvania.

It should be mentioned that there is an interval totaling about 200 feet composed of shales, sandstones and an occasional limestone between the Nineveh sandstone and the Gilmore coal in the section just given. It is quite probable that with further work on the stratigraphy of the beds included in that interval, correlations with beds which appear to be at the same stratigraphic horizons in West Virginia could be made.

Locality 12.—Union District, Putnam County, West Virginia

Fossils were found along the north side of the road from Liberty to Paradise, about four-tenths of a mile southwest of Liberty, West Virginia. The approximate elevation appears to be near 1,000 feet above sea level.

The fossil-bearing sandstone is greenish-gray in color and is 25(?) feet or more in thickness. It was being quarried for road material at the place where the fossils were collected.

Since no sections were made here, nor was the locality revisited, the stratigraphic position of this sandstone is not known. From the Maps of General and Economic Geology (C. E. Krebs, 1911; and C. E. Krebs and D. D. Teets, 1914) it appears that the fossil-bearing sandstone may be the Jollytown (of Hennen) in the lower part of the Greene group. This identification is not certain and it is possible that the bed in question may be the Hundred sandstone, 30 feet or more below the Jollytown sandstone and included in the upper part of the Washington group.

Locality 13.—Proctor District, Wetzel County, West Virginia

An outcrop containing fossils was found on the east side of the road which runs southwest from St. Joseph to the confluence of Brushy Fork and Whetstone Creek, just one and two-tenths miles from the Catholic Church at Saint Joseph. This outcrop is just above a hair-pin turn in the road and about one-tenth of a mile east of the bridge over Whetstone Creek. The approximate elevation of the outcrop is 1,020 feet above sea level.

Fossils were found in a fresh-water limestone, gray in color and two to four inches thick, and in a few inches of gray shale immediately beneath this limestone.

The stratigraphic positions of the fossil-bearing limestone and shale have not been definitely determined, but apparently they are near the stratigraphic horizon of the Fish Creek coal.

Locality 14.—Liberty District, Marshall County, West Virginia

A few fragmentary fossils were taken from a bed which outcrops on the east side of the Cameron-Bellton Road (U. S. Route No. 250), just four-tenths of a mile (car mileage) northwest of the bridge over the Pennsylvania Fork of Fishing Creek. This bridge is about four-tenths of a mile west of Bellton. The elevation of the fossil-bearing bed may be from 1,000 to 1,050 feet above sea level.

Fossils were found in a light gray limy shale. The thickness of the bed is not known.

The stratigraphic position of the bed is not known, but from the Bellton Sections given by Hennen (1909: 141-142) it is evident that it is well above the Upper Washington limestone and apparently near the horizon of the Fish Creek coal.

Locality 15.—East Finley Township, Washington County, Pennsylvania

The quarry in which fossils were found is on the road which runs south from Claysville, Pennsylvania, along the ridge dividing the drainage of Buffalo Creek (to the east) and Robinson Run (to the west). The quarry is on the east side of this road (Pennsylvania Route No. 231), two and two-tenths miles south-southeast of the town limits of Claysville as indicated on the U. S. Geological Survey Map of the Claysville Quadrangle. The approximate elevation at the quarry is 1,460 feet above sea level.

The fossils were found in one of the several thin limestones which outcrop in the quarry. It is not known from which of the thin beds of limestone the fossils came. The total thickness of the limestones outcropping here is estimated to be eight to ten feet.

This fossiliferous limestone appears to be the Nineveh limestone. From the Structure and Economic Geology Map in the Claysville Folio (M. J. Munn, 1912) it appears that the quarry is about 320 feet above the horizon of the Upper Washington limestone, which bed was used as the key bed for the structure contours. The interval between the Upper Washington limestone and Nineveh limestone, as determined from figures given by Munn (1912: 7), is 315 feet.

Locality 16.—Tucker District, Wirt County, West Virginia

The fossil-bearing stratum outcrops a short distance, probably less than half a mile, south of Limestone Hill, West Virginia. The outcrop is on the east side of the road from Limestone Hill to Lockhart P. O. (U. S. Route No. 21). The elevation of the outcrop is uncertain but appears to be about 1,000 feet above sea level.

The fossils were found in the fourth prominent limestone to be seen outcropping along the east side of the road as one proceeds south down the hill from Limestone Hill. This limestone and a few inches of gray shale immediately above it were found to be fossiliferous.

This limestone is apparently the Niniveh limestone and the three

limestones above it appear to be the Lower, Middle, and Upper Rockport limestones. R. W. Whipple and E. C. Case (1930), who collected fossils from the Upper Rockport limestone at this locality, also mention the occurrence here of the Nineveh, Lower Rockport and Middle Rockport limestones.

Locality 17. — Liberty District, Marshall County, West Virginia

Three localities were found at different levels along the road which leads south toward Howard, West Virginia, from a schoolhouse which is about four-tenths of a mile northeast of Adaline, West Virginia. In addition to locality 17, there are localities 26 and 32 which are described later in this paper.

Locality 17 is three-tenths of a mile east of Adaline and about two-tenths of a mile south-southwest of the schoolhouse mentioned in the paragraph above. The outcrop from which the fossil was taken is at the south side of the road. The approximate elevation at this point is 1,000 feet above sea level.

A fresh-water limestone two feet thick was found to contain fossils. This limestone is compact in the lower one foot but is shaly in the upper portion. It was from this upper shaly part of the bed that the specimen was taken. This fossiliferous limestone is no. 26 in the Adaline Section given below.

The Adaline Section is included here because it was used in attempting the identification of fossiliferous strata at localities 17, 26, 27 and 32.

Adaline Section

This is a hand-leveled section made in 1936 by John J. Burke and the writer. The base is at water level on Fish Creek, 50 feet up-stream (south) of the bridge crossing that creek, seven-tenths of a mile northeast of Adaline, West Virginia. The section was made from that point in a general southerly direction along the road toward Howard, West Virginia. The top of the section is near the top of the ridge at the lane leading to the first farm house on the west side of the road. The lane at which the section ended is one and one-tenth miles south of the starting point at the base of the section.

Top of Section

		<i>Thickness</i>		<i>Total</i>	
		<i>Ft.</i>	<i>In.</i>	<i>Ft.</i>	<i>In.</i>
80.	Concealed	5		568	1
79.	Sandstone, massive, brown	16		563	1
78.	Concealed	4		547	1
77.	Limestone	1		543	1
76.	Shale, red and gray	5		542	1
75.	Shale, red in upper part, concealed below	6		537	1
74.	Concealed	11		531	1
73.	Sandstone, massive	5		520	1
72.	Concealed	11		515	1
71.	Shale and sandstone	21		504	1
70.	Limestone, fossiliferous		5	483	1
<i>(Locality 32)</i>					
69.	Shale, red	8		482	8
68.	Sandstone, massive	8		474	8
67.	Shale, red and green	2		466	8
66.	Sandy shale, variegated	14		464	8
65.	Shale, red	5		450	8
64.	Shale, sandy, gray	6		445	8
63.	Shale, red	7		439	8
62.	Sandstone	8		432	8
61.	Shale, brown and red	19		424	8
60.	Concealed	5		405	8
59.	Shale, dark		6	400	8
58.	Sandstone	7		400	2
57.	Shale	1	6	393	2
56.	Sandstone	4		391	8
55.	Shale, red; large limy nodules in lower part	4		387	8
54.	Sandstone, calcareous		7	383	8
53.	Shale, bluish, nodular near top	7		383	1
52.	Concealed	11		376	1
51.	Limestone	1		365	1
50.	Shale	2	6	364	1
49.	Limestone		7	361	7
48.	Concealed with red shale showing near base	5		361	
47.	Shale, gray, carries plant fossils	13		356	
46.	Shale, clayey, with coaly streaks		7	343	
45.	Coaly shale		2	342	5
44.	Shale, limy; with limy nodules, large in upper part, occasional bone fragments	5	9	342	3
43.	Limestone, weathers brownish, fossiliferous		7	336	6
<i>(Locality 26)</i>					
42.	Shale, red; grades upward into limy shale	6	10	335	11
41.	Sandstone	6		329	1
40.	Concealed with red shale showing near base	4		323	1
39.	Shale, red and green, sandy at base	10	6	319	1
38.	Shale, sandy	16		308	7
37.	Shale, green, poorly laminated	1		292	7
36.	Sandstone	5		291	7
35.	Shale, brown and red	7		286	7
34.	Limestone, sandy and irregular		4	279	7
33.	Shale, sandy, reddish	1		279	3
32.	Sandstone	1		278	3
31.	Shales, red and green	6		277	3
30.	Shale, sandy	2	6	271	3

(Continued on page 28)

		Thickness		Total	
		Ft.	In.	Ft.	In.
29.	Shale, red and brown	5	6	268	9
28.	Sandstone	2	6	263	3
27.	Shale, red and brown	4		260	9
*26.	Limestone, shaly in upper portion, fossiliferous in shaly part (<i>Locality 17</i>)	2		256	9
25.	Shale, sandy, calcareous at top	9		254	9
24.	Limestone, sandy irregular		4	245	9
23.	Shale, blue-gray, with limy nodules	5	6	245	5
22.	Sandstone, gray, thin-bedded near base	12		239	11
21.	Sandy shale in lower four feet; concealed above	21		227	11
20.	Sandstone, massive below, thin-bedded above	13	6	206	11
19.	Shale, brown and clayey	8		193	5
18.	Clay		3	185	5
17.	Shale, sandy, grading upward into clayey shale	5	6	185	2
16.	Sandstone in lower six feet; shale above	12		179	8
15.	Shale, clayey, brownish-green	8		167	8
14.	Sandstone, thin-bedded and gray	16		159	8
13.	Concealed	39		143	8
12.	Limestone		6	104	8
11.	Concealed, some red shale at top	39		104	2
10.	Shale, brown and gray	5	6	65	2
9.	Shale, blue with flat concretions	4	6	59	8
8.	Shale, carbonaceous	1	6	55	2
7.	Limestone		2	53	8
6.	Shale, sandy	4		53	6
5.	Sandstone	1		49	6
4.	Shale, blue	5		48	6
3.	Limestone (carries bone fragments; none collected)		6	43	6
2.	Shale, blue, with limy nodules	11		43	
1.	Concealed to level of Fish Creek, 50 feet south of the bridge	32		32	

* The identification of this bed (no. 26) containing fossils at locality 17 is not certain. From the position of the Nineveh limestone at about 1,090 feet in the Lynn Camp Section (Hennen, 1909: 87-89) and from the structure as shown on the Map of General and Economic Geology (Hennen, 1909) it appears that the Nineveh limestone should occur at about 1,000 feet at Adaline, as does this particular stratum. (The Lynn Camp Section was made about three miles west of Adaline.) From those figures alone it appears that the stratum in which the fossil was found may be the Nineveh limestone.

At the other localities found nearby, (localities 26, 27 and 32) stratigraphic determinations are dependent upon this rather uncertain identification of bed no. 26 of the Adaline Section at locality 17 as the Nineveh limestone.

Locality 18. — Clay District, Marshall County, West Virginia

The fossil-bearing stratum outcrops on the north side of the northern ridge, dividing the valleys of Hog Run and Fish Run. The outcrop is about eight-tenths of a mile due east of the southern end of Captina Island which is in the Ohio River, between Captina, West Virginia, and Thompson P. O., West Virginia. This locality is about two miles southwest of locality 20. The approximate elevation of the outcrop is 1,240 feet above sea level.

Fossils were found in a thin fresh-water limestone which resembled the limestone of locality 20.

The exact stratigraphic position of the fossiliferous stratum is not known. From its apparent elevation it seems probable that the bed in question is at the horizon of either the Lower Rockport limestone or the Nineveh limestone. More field work would be necessary to definitely identify this fossil-bearing limestone.

Locality 19. — Liberty District, Marshall County, West Virginia

A fossil was found on the bank at the east side of the Bellton-Littleton Road (U. S. Route 250), three-tenths of a mile southwest of Bellton, West Virginia. The approximate elevation at this point is 1,160 feet above sea level.

The fossil was not found in place and the stratum from which it came was not definitely determined. The matrix adhering to the fossil was a light gray shale. It is probable, but not certain, that the fossil came from one of the shales between the several thin limestones which outcrop along the road at this place. This limestone horizon is composed of four or five thin layers of limestone which have a total thickness of about eight feet.

The stratigraphic position of this limestone horizon is not certain, but it may be at or near the Nineveh limestone. It appears that these thin limestones (at an elevation of about 1,160 feet) are approximately 260 feet above the Jollytown coal (of I. C. White), which according to Hennen (1909: 202) outcrops at about 900 feet above sea level, one-fifth of a mile below Bellton. The interval between the Jollytown coal and the Nineveh limestone was 270 feet in Hennen's Littleton Section (1909: 148-149), made about five miles southeast of locality 19.

Locality 20.—Clay District, Marshall County, West Virginia

One mile south of the mouth of Grave Creek, a fossiliferous limestone was found outcropping on both sides of the road (West Virginia

Route No. 88) leading south from Moundsville, West Virginia, along the ridge toward Riggs Knob. This point of outcrop is two to three-tenths of a mile north of Briggs schoolhouse. The approximate elevation of the fossiliferous stratum is 1,260 feet above sea level.

The fossils were found in a bed of fresh-water limestone three to four inches thick. It is underlain by five feet of red shale below which is a non-fossiliferous limestone two inches thick.

A hand-level measurement was made by John J. Burke and the writer from an outcrop of the Washington coal, at the side of the road about seven-tenths of a mile north of the fossil-bearing outcrop, up (south) to the fossiliferous stratum. This measurement showed that the fossiliferous limestone lies 334 feet above the Washington coal. When compared to Hennen's Hog Run Section (Hennen, 1909: 145-146), which was made about three miles southeast of the fossiliferous outcrop, it appears that the limestone 334 feet above the Washington coal may lie about 25 feet above the Nineveh limestone, if the stratigraphic intervals remain constant between Hog Run and locality 20. This thin, fossiliferous limestone at locality 20, therefore, may represent the horizon of the Lower Rockport limestone.

Locality 21.—Liberty District, Marshall County, West Virginia

This fossil locality is one and eight-tenths miles south of Cameron, West Virginia, on the road leading up (southeast) to the top of Big Run Ridge from the eastern branch of Big Run. The fossiliferous stratum outcrops along the north side of this road, just two-tenths of a mile (car mileage) northwest from its junction with the Cameron-Bellton Road (U. S. Route No. 250). The approximate elevation of the fossil-bearing bed is 1,280 feet above sea level.

Fossils were found in a light brown, fresh-water limestone four inches thick. A coal eight inches thick outcrops about 40 feet above the fossil bed. Another limestone about eight inches thick, in which no fossils were seen, outcrops between the fossiliferous stratum and the coal.

The stratigraphic position of the fossiliferous limestone is not known. However, from the fact that the Nineveh coal is said by Hennen (1909: 176) to outcrop at about 1,235 feet in this vicinity, it appears that the bed in which the fossils were found may represent the horizon of the Lower Rockport limestone, about 40 feet above the Nineveh coal.

Locality 22.—Proctor District, Wetzel County, West Virginia

A fossil-bearing stratum outcrops along the east side of the road from West P. O. to Silver Hill, West Virginia, about three-tenths of a mile east of West P. O. The approximate elevation of the outcrop is 1,140 feet above sea level.

A few fossils were collected here from a fresh-water limestone which is six inches to one foot in thickness. It weathers to a yellowish-brown but is a dark gray on a freshly broken surface.

It appears that this fossiliferous limestone is the same one shown in Hennen's West P. O. Section (Hennen, 1909: 154-156) to lie 60 feet above the base of the Nineveh limestone. This bed is apparently the Lower Rockport limestone.

Since the stratigraphic determinations of fossiliferous beds at the locality just given and at localities 23, 33, 34, 35, 36 and 37 (all of which are within three miles of West P. O., West Virginia) are in part based upon Hennen's West P. O. Section, the writer has reproduced it and part of a paragraph following it from the Marshall, Wetzel and Tyler County Report of the West Virginia Geological Survey by Ray V. Hennen (1909: 154-156).

"A section measured by aneroid northwest down hill road from the top of a high knob located one mile southeast of West P. O., on head of Middle Fork of Lynn Camp run, Proctor District, gave the following succession for the Dunkard series:

Section at West P. O. (Proctor District)

	<i>Feet Thickness</i>	<i>Feet Total</i>		
Sandy shale from top of knob	15.0	15.0	Proctor sandstones	151'
Sandstone and concealed to bench	50.0	65.0		
Concealed mostly sandstone to bench	30.0	95.0		
Concealed, mostly sandstone with steep bluff	55.0	150.0		
<i>Limestone, gray and hard, Windy Gap</i>	1.0	151.0		
<i>Coal, slaty (8"), Windy Gap</i>	1.0	152.0	51'	326'
Limy shale, concealed and flaggy sandstone	10.0	162.0		
Concealed and shale	40.0	202.0		
<i>Limestone, gray and hard</i>	1.0	203.0	17'	
Shale, sandy	2.0	205.0		
Concealed	14.0	219.0		
<i>Limestone, dark gray</i>	1.0	220.0	61'	
Concealed and sandstone	10.0	230.0		
Red shale	20.0	250.0		
Concealed, mostly sandstone, <i>Gilmore</i>	30.0	280.0		
Shale, variegated with 2 thin sandstones..	50.0	330.0	149'	
Concealed	55.0	385.0		
Flaggy sandstone and concealed	10.0	395.0		
Sandstone, massive, coarse, <i>Taylor</i>	20.0	415.0		
Concealed, sandstone and shale	14.0	429.0		
<i>Limestone, gray and hard</i>	1.0	430.0	48'	
Concealed	5.0	435.0		
Sandstone and concealed	20.0	455.0		
Sandstone, flaggy at bottom, <i>Nineveh</i>	20.0	475.0		
Shale	2.0	477.0		
Coal, <i>Nineveh (1090' L—A.T.)</i>	0.5	477.5	653'	
Black slate and flaggy sandstone	4.0	481.5		
<i>Limestone, gray and hard, silicious, Nin- evah to creek</i>	8.5	490.0		
Interval, supplied from average intervals between Wileyville and Denver	640.0	1130.0		
<i>Waynesburg coal</i>				

This is a very important section in that an almost vertical measurement is obtained for interval (326 feet) from the Nineveh up to the Windy Gap coal. This is the only exposure of the latter seam found by the writer in either Wetzel or Tyler. It is important for the reason that it shows that this latter seam comes 128 feet above the base of the Gilmore sandstone. In this interval are found 2 limestones, each 1 foot thick and 16 feet apart, the lower of which comes 60 feet above the base of the Gilmore sandstone. Another limestone appears in the

section, 47 feet above the Nineveh coal. There also appears to be 150 feet of measures on above the Windy Gap limestone, that are mostly made up of great sandstone masses. The Nineveh limestone is present in good thickness, as well as the Nineveh, Taylor and Gilmore sandstones. The interval from the Nineveh coal up to the base of the Gilmore sandstone is 197 feet."

Since the Rockport limestones had not been named or described when this section was made, it is possible that the limestone 60 feet above the Nineveh limestone may represent the Lower Rockport. If so, the interval between the Nineveh and Lower Rockport limestone is 16 feet more than in the Rockport, Wood County Section (Hennen, 1911: 46-47), the type section for the Rockport limestones.

Locality 23. — Proctor District, Wetzel County, West Virginia

A limestone containing fossils outcrops on the north side of the West P. O. - Newdale Road, about two-tenths of a mile southwest of West P. O., West Virginia. The approximate elevation at this place is 1,140 feet above sea level.

The fossil-bearing bed is a sandy, fresh-water limestone which weathers with a yellowish-brown surface to resemble the matrix of locality 22. However, a fresh surface is light brown in color and so differs from the matrix at locality 22, which is a dark gray on a fresh surface. The thickness of the fossiliferous limestone is more than three inches and probably less than one foot.

This outcrop is four-tenths of a mile west of locality 22 and appears to be at about the same elevation. This limestone may be a sandy phase of the fossiliferous limestone bed at locality 22 and is in this paper tentatively identified as the Lower Rockport limestone.

Locality 24.—Springhill Township, Greene County, Pennsylvania

On the west side of the Hundred, West Virginia-New Freeport, Pennsylvania Road (Pennsylvania Route No. 18) about one-half mile north of Garrison, Pennsylvania, a small collection of fossils was made. The elevation of the fossiliferous stratum is probably between 1,200 and 1,275 feet.

Fossils were found in a fresh-water limestone about six inches thick, which was overlain by one and one-half feet of gray shale and underlain by two feet of calcareous brown shale.

The stratigraphic position of the fossiliferous limestone is uncertain. From the fact that the Nineveh coal outcrops at an elevation of 1,210

feet (Hennen, 1909: 176) at a point two and two-tenths miles to the south, and from the structure as indicated at that point by Hennen (1909, Map of General and Economic Geology), it appears that the Nineveh coal should be present at very nearly the same elevation (1,210 feet) at locality 24.

Until further field observations have been made, the fossiliferous limestone is here tentatively identified as the Lower Rockport limestone.

Locality 25.—Battelle District, Monongalia County, West Virginia

A fossil-bearing shale outcrops on the east side of the road running southeast from Crossroads, West Virginia, at a point one and seven-tenths miles from that town. This road follows the valley of the eastern tributary of Miracle Run for a distance of about one mile south of Crossroads. The fossiliferous bed outcrops at a very sharp turn in the road, at an approximate elevation of 1,360 feet above sea level.

At this place a limestone horizon, represented by several thin limestones with a total thickness of about five feet, outcrops immediately beneath a massive brownish-green sandstone. The fossils were found in the light brown, limy shale included in the upper two feet of that limestone horizon.

With the aid of the Section at Crossroads, made by Hennen and Reger (1913: 94-95), it appears that the fossiliferous limestone is at the stratigraphic position of the Middle Rockport limestone, directly beneath the Taylor sandstone. However, since the elevation of the fossil-bearing bed is only approximately known, it is possible that the bed in question may represent either the Upper Rockport limestone about 30 feet higher or the Lower Rockport about 30 feet lower.

Locality 26.—Liberty District, Marshall County, West Virginia

One-tenth of a mile south of locality 17, and along the east side of the same road, another fossiliferous outcrop was found. This outcrop is about three-tenths of a mile southeast of Adaline, West Virginia. The approximate elevation of the fossil-bearing bed is 1,075 feet above sea level.

Fossils were found in a fresh-water limestone which is gray on a fresh surface, but weathers brownish. The thickness of this stratum is seven inches. This limestone is no. 43 in the Adaline Section which is given following locality 17 in this paper.

This limestone has not been definitely identified. If the tentative identification of the fossiliferous stratum at locality 17 as the Nineveh limestone is correct, it appears that the bed in question here (at locality 26) may be the Middle Rockport limestone since it occurs 81 feet above what appears to be the Nineveh limestone. The interval from the base of the Nineveh limestone to the base of the Middle Rockport limestone is 81 feet in the type section for the Rockport limestones in Wood County (Hennen, 1911: 46). Further identifications and correlations of the Rockport limestones in Marshall and Wetzel counties must be made before the correct intervals in this area can be known.

Locality 27.—Meade District, Marshall County, West Virginia

A fossil-bearing limestone was found scattered along the surface of the hill at a point which is six-tenths of a mile west of the confluence of Maggoty Run, with the southernmost tributary entering it from the west. The place where the fossils were found is one-tenth of a mile southwest of the end of the only private road, which runs west from the public road leading up onto Goshorn Ridge from the mouth of Maggoty Run. The approximate elevation at the point of collection is 1,120 feet above sea level.

A fresh-water limestone about six inches thick was found to carry fossils. The matrix is gray, but weathers light brown.

The stratigraphic position of this stratum is not definitely known. Although this limestone was not in place, it was evident from the extent of the float along the hillside, and from the height of the hill itself (1,140 feet), that the limestone was not far below its original position. From both megascopic and microscopic inspection it appears to be identical to the limestone at locality 26 (bed no. 43 in Adaline Section) which outcrops about one and two-tenths miles to the southeast. Also, at both of these localities the interval to the Pittsburgh coal from the fossiliferous limestones appears to be about 845 feet, from the Map of General and Economic Geology (Hennen, 1909). Hence, it is possible, as in the case of locality 26, that the limestone at this locality may represent the horizon of the Middle Rockport limestone.

Locality 28.—Battelle District, Monongalia County, West Virginia

On the south side of the road (West Virginia Route No. 7) between Cottontown and Wadestown, West Virginia, about 100 yards east of the Wetzel County-Monongalia County line, a number of fossils were collected. The elevation of the top of the fossil-bearing bed is 1,285

feet, as figured from a U. S. Coast and Geodetic Survey bench mark which is located at the north side of the road about 200 feet west of the place where the fossils were collected.

The fossils were found in a soft, light gray shale several feet thick which underlies five and a half feet of limestones and shales.

Hennen and Reger's identification of the Lower Rockport limestone at an elevation of 1,235 feet (Hennen and Reger, 1913: 176), about three-tenths of a mile northeast of this locality, was used to determine the stratigraphic position of the fossil-bearing stratum. As calculated from the above elevation, the bed in question lies about 50 feet above the Lower Rockport limestone. This interval of 50 feet above the Lower Rockport limestone would make it appear that the fossiliferous shale is between the stratigraphic positions normally occupied by the Middle and Upper Rockport limestones. Or it is possible that the intervals have changed, and the fossil-bearing shale might be included in either the Middle or Upper Rockport limestone depending on the extent of change in intervals.

Locality 29.—Franklin District, Marshall County, West Virginia

A few fragmentary fossils were taken from outcrops on both sides of the road, which runs along the ridge between Long Run and Whetstone Creek, at a point one and four-tenths miles east-northeast of the village of Fairview (formerly called Ella), West Virginia. This locality is between a cemetery on the east side of the main road and a private road which leaves the west side of the main road about 150 feet south of the cemetery. Elevation is about 1,330 feet above sea level.

A fresh-water limestone, gray to tan in color, and containing many inclusions of shale, carried the fossils. This limestone is at least three inches thick and possibly as much as one foot in thickness.

The stratigraphic identification of this limestone is not certain. From the structure contours on the Pittsburgh coal (Hennen, 1909: Map of General and Economic Geology) and Pittsburgh coal-Nineveh coal intervals given by Hennen (1909: 175), it would appear that the fossiliferous bed lies approximately 115 feet above the Nineveh coal. This interval of 115 feet above the Nineveh coal, when compared to sections made by Hennen (1909: 105, 155), places the bed in question at, or not far above, the horizon of the Taylor sandstone. If these figures, which are necessarily only approximate, are correct, it would appear that the bed in question may represent the horizon of the Upper Rockport limestone just above the Taylor sandstone.

Locality 30.—Franklin District, Marshall County, West Virginia

This locality is about one-tenth of a mile south of locality 29 (see above) on the west side of the main road. Fossils were found in limestone blocks, which had been piled up across the road from the barn owned by Mr. T. L. Yoho. Unfortunately, the exact source of the limestone is not known. However, it is most likely that these pieces of fossiliferous limestone came from the same bed as at locality 29—possibly the horizon of the Upper Rockport limestone.

Locality 31.—Tucker District, Wirt County, West Virginia

A fossiliferous limestone outcrops on the east side of the road from Limestone Hill to Lockhart P. O. (U. S. Route No. 21), less than half a mile south of Limestone Hill, West Virginia. The elevation of this limestone is 1,060 feet (?) above sea level.

The fossils were found in the first prominent limestone outcropping along the east side of the road south of Limestone Hill. The thickness of this bed was not noted, but is probably less than two feet.

This limestone appears to be the Upper Rockport limestone which was recognized at this place by Whipple and Case (1930: 371) when they collected fossils from it in 1930.

Locality 32.—Liberty District, Marshall County, West Virginia

This locality is two-tenths of a mile south of locality 17 and one-tenth of a mile south of locality 26, along the east side of the same road as at both of these localities. This fossiliferous outcrop is about three and one-half tenths of a mile southeast of Adaline, West Virginia. The approximate elevation at the point of outcrop is 1,220 feet above sea level.

The fossil-bearing bed is a fresh-water limestone with a thickness of five inches. This limestone is in two layers, and fossils were found in the upper layer which is two inches thick. This bed is no. 70 in the Adaline Section which was given with locality 17 on a preceding page of this paper.

The fossiliferous limestone here has not been definitely identified. If the tentative identification of the fossiliferous limestone at locality 17 as the Nineveh limestone is correct, then it is possible that the limestone (no. 70 in the Adaline Section) at locality 32, 228 feet above locality 17, may represent the horizon of the Gilmore limestone.

Locality 33.—Proctor District, Wetzel County, West Virginia

Fossils were collected from an outcrop on the southwest side of the road on Brock Ridge, one and three-tenths miles southwest of West P. O., West Virginia, and one and four-tenths miles southeast of Newdale, West Virginia. The approximate elevation of the outcrop is 1,380 feet above sea level.

A brown and gray clayey shale about six inches thick was the bed from which fossils were taken. Directly above this shale is a fresh-water limestone two feet thick. Beneath the fossiliferous shale is a brown sandy shale.

A hand-leveled section was made by John J. Burke and the writer at this locality. This section was carried up to an outcrop of the Windy Gap coal at a point three-tenths of a mile north of the fossil-bearing outcrop. The section showed that the fossiliferous shale is 53 feet beneath the Windy Gap coal. The two-foot limestone immediately above the fossil-bearing bed is apparently the unnamed limestone, which in the West P. O. Section of Hennen (1909: 154-155) reproduced following the description of locality 22 in this paper, is 50 feet beneath the Windy Gap coal.

Locality 34.—Proctor District, Wetzel County, West Virginia

Along the north side of the Newdale — West P. O. (West Virginia) Road, about two-tenths of a mile northeast of Newdale, a few fossils were collected. The approximate elevation of the outcrop is 1,460 feet above sea level.

The fossil-bearing bed is a fresh-water limestone two to four inches thick which is light brown on weathered surface and gray on fresh fracture. A limestone similar in appearance and thickness, but not containing vertebrate fossils, was observed here 15 feet beneath the fossiliferous stratum.

From the information the writer has about this locality, it appears that the bed in question is most likely about 50 feet below the Windy Gap coal. In Hennen's West P. O. Section, which was made about two and one-half miles east of this outcrop, there are two unnamed limestones 16 feet apart, and the uppermost of these is 50 feet beneath the Windy Gap coal. Although both of those limestones in the West P. O. Section are one foot thick, it is possible that they are thinning out toward the west and that the two limestones two to four inches thick at Newdale represent those same limestone beds. Until more accurate

elevations on these beds are made in the field, it is not possible to give a more exact stratigraphic determination for the fossiliferous limestone at this locality.

Locality 35.—Proctor District, Wetzel County, West Virginia

At this locality a collection was made from an outcrop along the south side of the West P. O. - Silver Hill, West Virginia, Road about six-tenths of a mile east of West P. O. This outcrop is about one-tenth of a mile east of Rosefield schoolhouse. The approximate elevation at the point of outcrop is 1,370 feet above sea level.

The stratum which contained the fossils is a brown sandy shale about two feet thick which grades downward into a siliceous limestone.

From the structural contours based on the Pittsburgh coal on the Map of General and Economic Geology (Hennen, 1909), it appears that this outcrop underlies the Windy Gap coal horizon by about 40 feet. It seems probable that the fossiliferous, sandy shale at this locality is directly over the limestone which in Hennen's West P. O. Section is just 50 feet beneath the Windy gap coal. Further field work would be necessary to make a positive identification of the fossil-bearing bed.

Locality 36.—Center District, Wetzel County, West Virginia

A fossiliferous bed of sandstone was found along the north side of the road leading from Silver Hill, West Virginia, to Miller Ridge Church. This outcrop is six-tenths of a mile northeast of Silver Hill, West Virginia. At the point of outcrop the approximate elevation is 1,380 feet above sea level.

Fossils were found in a sandstone just one inch thick. This sandstone is reddish-brown to light tan in color. Five feet below the fossiliferous sandstone is a freshwater limestone one foot thick.

The stratigraphic position of the fossil-bearing bed is uncertain. From the structure contours on the Pittsburgh coal, on the Map of General and Economic Geology (Hennen, 1909), it appears that the bed in question may be five feet above that limestone, one foot thick, which in Hennen's West P. O. Section is 50 feet below the Windy Gap coal. (This locality is less than three miles northeast of West P. O. where the above mentioned section was made by Hennen.) Further field work would be necessary to definitely place the stratigraphic position of the fossiliferous bed.

Locality 37.—Proctor District, Wetzel County, West Virginia

Seven-tenths of a mile west of Silver Hill, West Virginia, on the east side of the road from Silver Hill to Macedonia School, a small collection of fossils was made. At the point of collection there is an abrupt right angle turn in the road. The approximate elevation of the outcrop is 1,420 feet above sea level.

The fossiliferous stratum is a brown limy clay about four inches thick which overlies a fresh-water limestone one foot in thickness.

The stratigraphic position of this fossil-bearing bed is not definitely known. It is most likely either just above the limestone which in Hennen's West P. O. Section was 50 feet beneath the Windy Gap coal, or just above the Windy Gap limestone. Without further field observations it is impossible to definitely determine the exact stratigraphic position of this fossiliferous stratum.

SUMMARY

Although it had long been known that fossil tetrapods occurred in the Pennsylvanian and Permian rocks of this region, the field parties which found the new localities described in this paper demonstrated that those fossils are much more common than had been generally believed. A total of 37 localities yielded vertebrate fossils and only one locality (no. 31) was not new, Whipple and Case (1930: 371) having made a collection there earlier. Among the 37 localities, there were represented 13 stratigraphic horizons at which neither amphibian nor reptilian fossils had been previously found. At locality 3 were collected the only tetrapod fossils so far reported from the entire Monongahela group.

Before this paper had been prepared for publication (June 1942), there had been described four localities (J, K, L, M) at which vertebrates had been collected within the upper part of the Greene group, from the base of the Nineveh limestone up to the top of the Gilmore limestone. The new localities described in this paper have increased that number to 22, clearly indicating that that part of the Greene group is particularly fossiliferous.

Of special interest are the five localities near West P. O., West Virginia, which appear to be stratigraphically about 50 feet below the Windy Gap coal (localities 33, 34, 35, 36, 37). If the strata at these places are correctly identified, they are the youngest of the Paleozoic rocks in eastern United States known to have yielded vertebrate fossils.

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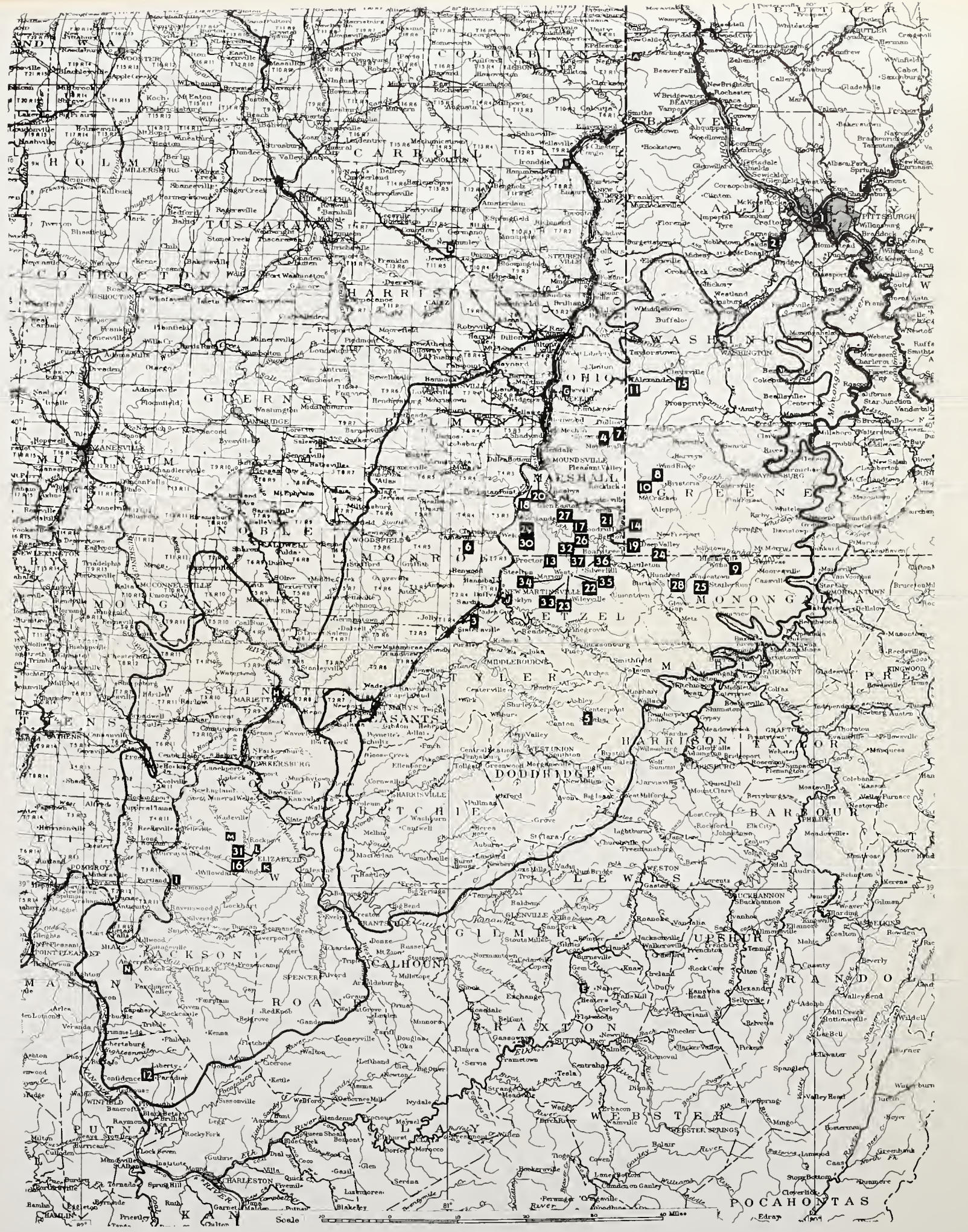
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MAP
OF NORTHWESTERN WEST VIRGINIA AND THE ADJACENT
PORTIONS OF OHIO AND PENNSYLVANIA
SHOWING OCCURRENCES OF UPPER PENNSYLVANIAN AND
PERMIAN TETRAPODS

- Previously worked localities..... A, etc.
- New Carnegie Museum localities..... 1, etc.
- Principal area of Dunkard series enclosed within heavy line 
- State boundary lines 
- County boundary lines 

Adapted from U. S. G. S. Base Maps of West Virginia, Ohio, and Pennsylvania which have here been reduced to a scale of approximately 18.5 miles to the inch.



ART. 2. LATE PENNSYLVANIAN AND EARLY PERMIAN VERTEBRATES OF THE PITTSBURGH-WEST VIRGINIA REGION

BY ALFRED SHERWOOD ROMER

Director, Museum of Comparative Zoölogy

INTRODUCTION

The region of the Ohio River drainage in western Pennsylvania, West Virginia and eastern Ohio is unique in America in the presence of an almost unbroken series of essentially continental sediments extending from the typical Carboniferous on into the Permian. There is thus afforded the opportunity of obtaining a sequence of faunas extending on from those of the classical Pennsylvanian to assemblages contemporaneous with the vertebrates of the early Permian Redbeds of the American Southwest. Until recently, little information was available concerning these faunas. A notable advance in our knowledge is afforded through collections made by Carnegie Museum parties in the 1930's. Some account of this work is given in the accompanying geological paper by Mr. William E. Moran and in earlier published notices by the party leader, Mr. John J. Burke (1935, 1937).

If the bulk of the material resulting from these expeditions is compared with that obtainable by an equal amount of labor from, say, the classical Redbeds region of northcentral Texas, one tends, unthinkingly, to be somewhat contemptuous of it. Much consists of isolated and often incomplete vertebral elements, scales and small scraps of sculptured bone—material that a Texas collector would disdain. But, despite the lack of morphological "quality," these specimens are documents of the highest value. The Dunkard material gives us a knowledge of the Permian fauna of a region far removed from the Redbeds regions of the Southwest; the late Pennsylvanian sites, although unfortunately few in number, shed valuable light on the Carboniferous-Permian transition. The collection of these newly assembled materials was a task far harder than that of the Texas "bone-hunter." In the latter semi-arid area, there are extensive fossiliferous exposures of easily worked clays; in the Pittsburgh district, exposures are few and scattered and the main materials are hard limes and "mudstones," worked with the greatest difficulty. Mr. Burke, Mr. Moran and their associates deserve sincere praise for their enthusiasm and persistence in a difficult and discouraging task.

For the most part, the present paper is concerned with the description of this new material collected by the Carnegie Museum explorations of 1934-37. In order to round out our picture of the faunas, however, I have included some account of earlier vertebrate finds from the late Pennsylvanian and Permian of the region and have restudied certain of these materials, particularly the Pitcairn Conemaugh vertebrates in the Carnegie Museum collections, discovered by Raymond and described by Case (1908). I have further included a description of a Dunkard reptile from the collections of the U. S. National Museum. Although the interest of the faunas lies mainly in the reptiles and amphibians present, and to a lesser extent in the freshwater fishes, I have included brief notes on earlier finds of fishes, fresh or salt, from beds of appropriate age in this area. I have not discussed the typical Pennsylvanian faunas of the Allegheny group, but have confined treatment to the Conemaugh and Monongahela groups of the late Pennsylvanian and the Dunkard formations — Washington and Greene — which follow them and close the cycle of deposition in this region.

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DESCRIPTIONS

Below, I have discussed the material in systematic sequence, beginning with representatives of the "shark" groups, followed in order by

bony fishes, amphibians, reptiles and miscellaneous remains. It must be understood that many of the identifications are tentative and open to doubt because of the fragmentary nature of the material.

Mr. Moran, in his accompanying paper, has listed the various localities visited by the Carnegie Museum parties as a numbered series and has referred alphabetically to localities from which others have obtained tetrapod remains. I have used these numbers and letters throughout and have given more detailed citations only in the case of localities for marine fishes, footprints, etc., with which Moran has not concerned himself. Specimen numbers (unless otherwise specified) refer to the catalogue of vertebrate fossils in the Carnegie Museum.

Acanthodes cf. marshi

At locality 26 several spines were found, flattened ovate in section, with one or both marginal areas thinned and set off from the main portion (no. 8529). These appear to be acanthodian in nature (cf. Watson 1937, pl. 13) and presumably belong to the typically Permian genus *Acanthodes* [*Acanthoessus*]. This is the first identification of an acanthodian in the American Permian and, except for the Upper Pennsylvanian of Mazon Creek, the only identified find of any acanthodian in this continent later than the Devonian. There is no feature visible in these spines by which they can be distinguished from *A. marshi* from Mazon Creek (Eastman 1902: 93-94, pls. 6, 7).¹

Cladodus occidentalis

Raymond (1910: 156) reports this marine shark tooth type from the Ames limestone of the Conemaugh group in the Pittsburgh region. Teeth of this sort are known to occur in a variety of primitive sharks of the cladoselachian and hybodontoid groups, ranging from Upper Devonian to Lower Permian.

Agassizodus variabilis

Raymond (1910: 156) reported teeth of this hybodont shark from the Ames limestone of the Conemaugh group. The present collections contain a tooth of this type from locality 1 (no. 8520) and a damaged tooth (no. 8615), which may be *Agassizodus*, from locality 2 in the Conemaugh group. A fragment of a hybodont spine (no. 8580) from locality 1 may well belong to this genus.

¹ *A. newberryi* from the same locality may well be based on young individuals of *A. marshi*.

Petalodus ohioensis

Teeth of the common marine "pavement tooth" shark genus *Petalodus* are relatively abundant in the marine elements of the Conemaugh. They are reported from the Ames limestone in the Pittsburgh region (Raymond 1910: 148), Athens, Ohio (Condit 1912: 279), and Caldwell, Ohio (Condit 1912: 285); from the Cambridge limestone at Northrup, Ohio (Condit 1912: 273) and Cambridge, Ohio (Safford 1853: 142); the Pine Creek limestone in the Pittsburgh region (Raymond 1910: 156); the Brush Creek limestone at Bens Creek, Pennsylvania (Leidy 1856: 161; 1873: 312, 353; Raymond 1910: 148); the Portersville limestone at Santy, Ohio (Condit 1912: 279). There is little ground for specific determination in this material. Two species of *Petalodus* have been described from the Conemaugh, *P. ohioensis* of Safford (1853: 142) having priority over *P. alleghaniensis* of Leidy (1856: 161).

Fissodus inaequalis

A second petalodont reported by Raymond (1910: 156) from the Ames limestone of the Conemaugh.

Deltodus angularis

A common genus of the bradyodont "shark" family Cochliodontidae, *Deltodus* is reported by Raymond (1910: 156) from the Brush Creek, Pine Creek and Ames limestones of the Conemaugh.

Peripristis semicircularis

A second cochliodont, reported by Condit (1912: 287) from the Ames limestone at New Concord, Ohio.

***Dittodus* sp.**

Under this name may be provisionally ranged the remains, cited below, of freshwater sharks of the type generally known as "pleuracanth"; such remains are common in these collections, as in most continental fossiliferous deposits of late Carboniferous and early Permian ages.

As usual, the most common finds are the characteristic two-pronged teeth usually termed *Diplodus* (preoccupied) or *Dittodus*. Such teeth are found at localities 1, 2, 4, 6, 16, 18, 20, 22, 25, 28, 29, 33, 35 and 37. Two teeth from locality L, tentatively identified by Whipple and Case as belonging to the reptile *Dimetrodon*, appear to be broken prongs of *Dittodus* teeth, of which identifiable specimens are also present in the material. Raymond (1910: 149, 156) notes the presence of "*Dip-*

lodus" teeth in the Birmingham shale and Woods Run beds of the Conemaugh formation in the Pittsburgh region. Price (1927: 228-229, fig. 10, pls. 20, 21; Price, Tucker and Haught 1938: 159) described "*Diplodus*" teeth from the "Round Knob" formation (Pittsburgh shales) of the Morgantown region of West Virginia. Stauffer (1916: 88) cited them from Shadyside, Ohio, in the Lower Washington limestone of the Washington formation; these teeth were formally described by Stauffer and Schroyer in 1920 (p. 147, fig. 40) as *D. washingtonensis*.

It is obvious from the above records that *Dittodus* was present throughout the time of deposition of late Pennsylvanian and early Permian deposits in the Pittsburgh region. Specific identification of isolated teeth is impractical in the present state of knowledge, since there was (as in modern sharks) wide variation in tooth types from one part of the jaws to another.

As in other areas, calcified remains of braincase and visceral arch cartilages are present in the material. Such cartilages are present in localities 1, 6, 20 and 28.

In "pleuracanth," a stout spine, typically with paired rows of denticles, projected from the occipital region of the braincase back over the "neck" region. Such spines are frequently referred to under the generic terms of *Pleuracanthus* (preoccupied), *Xenacanthus* and *Orthacanthus*. These spine types, with well-developed "tooth" rows extending well down the length of the spine, are found in various Carboniferous and Lower Permian localities including, amongst others, the Clear Fork beds of the Texas Permian. In the earlier Texas Wichita beds, however, the only spine type found with pleuracanth remains is that figured by Hussakof (1911, pl. 26, fig. 5) as *Anodontacanthus* (cf. Romer 1942: 227). Here the spine is relatively small. It may show two rows of tiny tubercles distally, but in some cases (as the result of wear) even these appear to be absent. In the present material, pleuracanth spines were found at locality 6, where four specimens were obtained (no. 8528), and localities 1 and 2, where there were fragments of such spines (no. 8527). These are of the "*Anodontacanthus*" type. Specimens lacking the distal portion show typical pleuracanth longitudinal striations but no denticles; one, which is nearly complete, distinctly shows rows of tiny denticles; another, complete to the tip, shows only faint traces of denticles.

Olson (1946: 286-288) discusses the tangled systematic situation in the pleuracanth. He concludes by using the term *Xenacanthus* for the late Carboniferous materials considered in his paper. Since,

however, the only spine material under consideration here is not referable to *Xenacanthus* and is, in fact, closer to *Orthacanthus*, I have preferred to use *Dittodus* as a "blanket" generic name.

Unidentified "Shark" Remains

Unidentified remains of fishes which may have been sharks or bradyodonts of one type or another have been reported from a number of late Pennsylvanian and Dunkard limestones in various instances. Raymond (1910: 148) reports that fish teeth are fairly common in the Ames limestone of the Conemaugh; these may include remains other than the five shark and bradyodont species noted earlier. Condit (1912: 38, 39, 283) reports fish teeth and bones from the Ewing limestone of the Conemaugh near Jewett and Caldwell, Ohio. Tilton (1930: 109, pl. 1, fig. 9) notes "denticles" from the Sewickley limestone of the Monongahela group at Oglebay Park, W. Va., and "sharks' teeth" which appear to be coeliodonts from the Elm Grove limestone of the Washington formation in the same area (Tilton 1930: 11, pl. 3, figs. 2, 74). Stauffer and Schroyer (1920: 146, pl. 12, fig. 36) describe a large spine from shales of the Washington formation at Clarrington, Ohio. Presumably this is a dorsal spine of a shark of some type. It is bluntly triangular in lateral view and bears an ornamentation of small tubercles which are apparently worn.

Cf. *Ectosteorhachis nitidus*

Crossopterygians of the *Megalichthys* type, familiar in the Carboniferous, are known to have survived as late as the Lower Permian in Texas, where numerous remains of *Ectosteorhachis* [*Megalichthys*] *nitidus* have been discovered. Scales comparable to those of *Ectosteorhachis* are present at localities 1 (no. 8522) and 26 (no. 8519). From locality 2 was obtained a clavicle (no. 8521) with the characteristic surface tuberculation of the *Megalichthys* group.

Sagenodus cf. *periprion*

The common lungfish of the late Carboniferous of both Europe and North America and of the early Permian Redbeds of the American Southwest is *Sagenodus*. Remains assignable to this genus are abundant in the present material. Such remains, never found articulated, include dermal bones of the skull roof, parasphenoid and pterygoid, lower jaw, operculum and shoulder girdle, quadrates and tooth plates. Materials are present at localities 1 (head plate, cleithrum, no. 8516), 4 (head plates, parasphenoid, tooth fragment, no. 8518),

6 (abundant remains, nos. 8500-8515, 8543), 26 (head plate, no. 8596), 29 (head plates), 31 (immature tooth) and 37 (plate fragments). *Sagenodus* remains are, thus, present throughout the entire vertical extent of the formations studied, from Conemaugh to Upper Greene. Most notable is locality 6, Cameron, Ohio, in the Washington formation of the Dunkard. Here, a quarry in gray shale and limestone yielded, besides lesser remains of other forms, large quantities of lungfish material.

The dermal plate material is all characteristically *Sagenodus*-like. Watson and Gill (1923:165-188) have described very similar assemblages from the English Coal Measures; Fritsch (1889, pls. 71, 72, 74, 75, 77, 78) has, as Watson and Gill note, described a similar series of plates; and large quantities of undescribed material of this sort are present in the Museum of Comparative Zoölogy collections from the Texas Redbeds. As in these other series, the Cameron materials show numerous variations which appear to be individual in nature or growth stages. Several large and presumably mature opercular bones measure 76, 87 and 83 mm. in greatest diameter and are thus slightly smaller than the opercular in Watson and Gill's restoration (1923, fig. 20). Specimens of mature "parietals" (bone *B* of Westoll's nomenclature, 1949) measure 46, 48 and 51 mm. in greatest length; these are figures well under those of the "parietal," figured by Watson and Gill (1923, fig. 1) in their restoration of the cranial roof of the English Coal Measures *Sagenodus*, and not far from the size of the young adult specimen of their figure 4D.¹ As compared with Texas *Sagenodus* specimens, there appears to be little difference in size of presumably mature elements and no observable morphological differences which might be used for specific differentiation.

There is little dental material except from Cameron, locality 6, in the Washington formation. From here were obtained about sixteen upper and eight lower tooth plates or fragments of plates, two of which are shown in Plate I, figures 1 and 2. Most of the upper plates have approximately ten tooth ridges, with some variation in the development of the small ridges at the posterior end of the plate; two plates, however, have eight ridges. A number of stages in growth and wear are represented, from a small tooth with a length of about 16 mm. to teeth which, while incomplete, appear to have measured

¹ The "× about 3" in the legend of figure 4 of these authors is obviously an error, and should be, as in other figures "× about 2/3."

48± mm. The tips of the ridges in mature teeth are comparable to those described by Romer and Smith for *S. ciscoensis* (1934, fig. 3D). The inner margin of the tooth is gently curved, without the marked angulation figured in *S. ciscoensis* (Romer and Smith 1934, fig. 5E). The lower plates show variations comparable to those of the upper ones. Estimated lengths range from 24 to 48 mm. (no exceptionally young specimens are present in the material). The number of ridges in the few complete Cameron specimens ranges from 10 to 13.

Specific identification is at present impractical, even in the case of the abundant Cameron specimens; *S. periprion* of Texas appears to be closest on present evidence. The writer some years ago (Romer and Smith 1934) attempted an interpretation of the American *Sagenodus* on the basis of the data then available, but abundant new material from the Texas Permian has made it clear that these findings are in need of revision.

Of unusual nature is a specimen, no. 8517, from locality 6. This includes the crushed skull and much of the body of a small vertebrate; the length of the skull as preserved, plus upwards of 20 body segments, is but 6 cm. Of the skull there are numerous fragmentary and disarticulated dermal plates with a shiny enamel-like surface. The body remains show no definite traces of vertebrae but include numerous curved and closely appressed rod-like structures essentially circular in section. At first glance one tends to interpret these as a ventral armor, but they are not jointed nor at all flattened. They thus appear to be the well-ossified ribs of a form in which there was little or no ossification of the vertebrae — a situation true of the lungfishes. The type of preservation is remarkably similar to that seen in the type of the contemporary lungfish *Megapleuron rochei* of Gaudry (1883, fig. 246), although the present specimen is much smaller. I have seen no trace of teeth in the crushed skull; it is probable, although not certain, that we are dealing with a young *Sagenodus* rather than a lungfish of some other type.

Palaeoniscoid Actinopterygians

In late Paleozoic days the commonest inhabitants of fresh waters appear to have been primitive ray-finned fishes, which were the predecessors and, as a group, the remote ancestors of the common teleost fishes inhabiting similar waters today. Such fishes were at one time lumped, for the most part, in the single genus *Palaeoniscus*. With increasing knowledge and the discovery of distinctive generic

types, they came to constitute a family; still later it became clear that they deserved recognition as a major group, the Palaeoniscoidea. Of delicate structure and generally of small size, these fish are usually found in disarticulated form and are exceedingly difficult to identify even generically.

From the region under discussion, I have described (Romer 1942: 218-220, pl. I, fig. 2) as *Amblypterus? stewarti* a large and nearly complete fish from shales immediately above the Upper Washington limestone and thus on the boundary between Washington and Greene formations of the Dunkard. Generic assignment was exceedingly dubious even in this case and is impossible at the present time in the case of isolated scales and small conical teeth, such as comprise all other presumed palaeoniscoid finds from this region. Scales of this sort have been found at localities 1, 2, 3, 16, 26 and 32 in the present material. At locality 26 was found a subrectangular dermal plate (no. 8519) with a delicate vermicular ornamentation, measuring 24 x 20 mm., which suggests an opercular element of a large platysomid. At locality 32 was found a small dentary (no. 8565), 8 mm. long as (incompletely) preserved, and bearing small sharp teeth, about 1/3 mm. long, at average distances of about 1/2 mm. The outer surface is somewhat longitudinally striate but unsculptured. Possibly this represents one of the contemporary palaeoniscoids.

From previous workers we may note that: Price (1927: 225-227, figs. 7, 8, pl. 19; Price, Tucker and Haught 1938: 158) describes small teeth of palaeoniscoid type from the Round Knob formation of the Conemaugh in the Morgantown, West Virginia region; Condit (1912: 293) reported fish bones and teeth which might pertain to palaeoniscoids from freshwater Conemaugh limestones in Ohio; from the Washington formation, Stauffer and Schroyer (1920: 146, figs. 38, 39) report small teeth which may be palaeoniscoid in the shales associated with the Elm Grove limestone near Beallsville, Ohio; Tilton (1930: 111, pl. 2, figs. 1, 3-6; pl. 3, figs. 1, 3, 5, 6; pl. 4A) describes palaeoniscoid scales and bone fragments from the Elm Grove limestone of Oglebay Park, West Virginia; from the Greene formation of West Virginia, the last writer (1926: 388, 394-395) reports palaeoniscoid scales or teeth from various horizons — the Nineveh shale, Jollytown shale, the shale above the Jollytown coal, the Fish Creek sandstone, Fish Creek shale and the Nineveh limestone; Whipple and Case (1930: 371) note presumably palaeoniscoid scales and teeth from locality L.

Cf. *Saurerpeton obtusum*

Fragmentary remains from locality 1 in the Conemaugh suggest the presence there of a flat-headed, small-limbed amphibian, perhaps antecedent to *Trimerorhachis* of the early Permian and possibly identical with *Saurerpeton* of the slightly earlier Linton canal.

A well-preserved parasphenoid of a small amphibian (no. 8530, pl. 1, fig. 5) is, in general proportions, comparable to that of *Trimerorhachis*, although it is of smaller size; the animal appears to have been, as in that genus, flat-skulled, for the body of the parasphenoid is expanded in a horizontal plane. The bone is embedded in a limestone block; the exposed surface appears to be the ventral one, since the surface of the corpus is nearly smooth and somewhat concave centrally. No carotid foramina are visible. The basiptyergoid articulations were movable and widely separated, facing anteriorly at the tips of processes which extend almost straight laterally from the base of the cultriform process. There is a faint development of a ridge, prominent in *Trimerorhachis*, which passes back laterally on either side behind the basiptyergoid process. The bone is incomplete posteriorly; there is little evidence of "basisphenoid" tubera, but there is present a low median ridge expanding fanwise posteriorly. Much of the cultriform process is preserved. It was expanded anteriorly; more posteriorly it was but moderately expanded and flattened, bearing on its assumed ventral surface a median ridge separating a pair of longitudinal grooves.

The form represented is certainly distinct from *Trimerorhachis*, the characteristic flat-headed form of the later Texas Redbeds, and I know of no other Lower Permian type from that region which is at all comparable. One is tempted to compare it with the Pennsylvanian tetrapods of the underlying Allegheny formation—the trimerorhachoids *Pelion* and *Saurerpeton* and the colosteids *Colosteus* and *Erpetosaurus* (cf. Romer 1947: 86-89, 116-117, 120-121, figs. 15, 16, 22). The bone is most similar to the parasphenoid of *Saurerpeton* in structure and is comparable in size.

From the same locality comes a small amphibian humerus, 14 mm. in length (no. 8562). There is no proof of the association, but it is not improbable that it comes from the same type of animal as the parasphenoid just described. *Saurerpeton* was a tiny-limbed form (cf. Moodie 1916: pl. 17) and the humerus is of an appropriate size for this genus. The entepicondyle is little developed and without a foramen; there is no projecting supinator process.

At locality 1 there are, as noted elsewhere, remains of a small diplocaulid, with a dermal bone structure of a finely pitted type. Not all such sculptured bone, however, pertains to this animal, and one small slab (no. 8559), on which are remains of skull elements otherwise indistinguishable from the diplocaulid, exhibits a small jaw definitely non-diplocaulid in nature. This is seen from the external surface and is incomplete anteriorly. It is relatively long, straight, slender and well-sculptured. Its length, as preserved, is 25 mm. and presumably was on the order of 30 mm. long when complete. It bears over a distance of 12 mm. a row of about 25 slender pointed teeth which show no evidence of labyrinthine folding. This is obviously the jaw of some small labyrinthodont, possibly the same as that to which the parasphenoid described above belongs, although certainly pertaining to a smaller individual.

***Glaukerpeton avinoffi*, gen. et sp. nov.**

The type of this new labyrinthodont is an imperfect skull (no. 8539) from the Conemaugh of locality 1 (fig. 1; pl. 2, fig. 7). This was

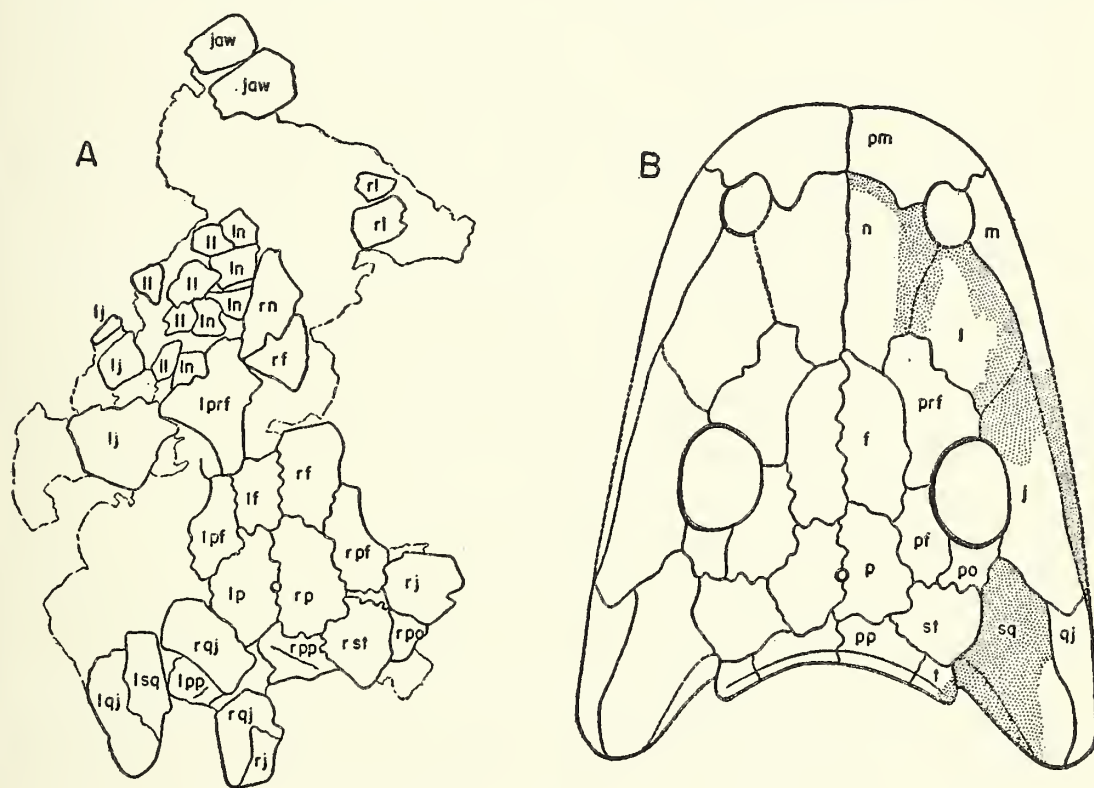


FIG. 1. *Glaukerpeton avinoffi*. A, attempted interpretation of materials of skull roof seen in the type (pl. 2, fig. 7). B, attempted restoration of skull roof pattern; stippled areas on right are portions of roof not present on either side of the specimen. Abbreviations: f, frontal; j, jugal; l, lacrimal; m, maxilla; n, nasal; p, parietal; pf, postfrontal; pm, premaxilla; po, post-orbital; pp, postparietal; prf, prefrontal; qj, quadratojugal; sq, squamosal; st, supratemporal; t, tabular. In A, r and l refer to right and left. $\times 1/5$.

found crushed flat on the surface of a large slab of impure limestone. After cleaning the upper surface, Mr. R. V. Witter performed the difficult task of removing the thin specimen from the block and cleaning the lower surface as well. As can be seen in plate 2, fig. 7, much of the dermal roof is exposed on the upper side; a few additional elements are seen on the under surface, together with crushed remains of palate and braincase.

Much of the skull table is well preserved and essentially in articulated position. The sculpture is more delicate than in the case of *Eryops*, with sharper, narrower ridges separating pits and valleys. The two parietals, with the usual foramen between them, are nearly complete, as are the two postfrontals antero-lateral to them. The large right supratemporal is present in position, and there is no intertemporal — a situation indicating that we are dealing with a rhachitome above the level of organization of the edopsoids and presumably an eryopsid. There are remains of both postparietals, including their occipital flanges, but they are somewhat displaced and partly covered dorsally by other elements. Poor remains of the left tabular are present on the under surface. The postorbital is present on the right side, and its outlines, including the orbital rim, are well seen from below; only a small part of the upper surface is visible. The “cheeks” are, unfortunately, poorly preserved and completely disarticulated. Of the jugal, fragments are present on the right side, lateral to the postfrontal, and a broad section lying below the orbit is present on the left. Both quadratojugals, with fused quadrates, are seen; that of the right side has been pushed over to the left of the skull table and broken in two. A small portion of the left squamosal is found with the left quadratojugal, but there are no other identifiable remains of that important element.

More anteriorly, the posterior portions of both frontals are in position. A piece of bone lying well ahead of the right frontal fits perfectly onto the articulated portion and hence is the anterior part of that bone. When articulated, the median margin lies close to the midline and hence the interfrontal bone characteristic of *Eryops* was not present. The left prefrontal is nearly complete and shifted but little from proper position. Anterior to it are two rows of bone fragments which, with some hesitation, I consider to represent, although incompletely, the left lacrimal and left nasal; to the right of the latter lies a considerable part of the right nasal. Bone fragments near the right anterior corner of the slab appear to be part of the right lacrimal.

On the lower surface of the slab is a stoutly developed premaxilla, comparable in general build with that of *Eryops*, and a long strip of bone (continued by a piece broken off the slab) which appears to represent the greater part of a maxilla. At the far front end of the slab are two lower jaw fragments; the inner surface of the larger fragment faces upward and can be seen to bear (in contrast with *Eryops*) a considerable battery of small coronoid teeth. The under surface of the slab shows various bone fragments representing palate and braincase, but I have been unable to interpret them satisfactorily.

It is impractical to separate the bones of this specimen for restoration; I have, however, made from full-sized photographs, cut-outs of the various pieces preserved and have attempted to reconstruct the skull roof on a clay form. After various essays the pattern restored in figure 1B is that which best fits the material preserved. The position of the suspensorium and the nature of the otic notch are the points of greatest uncertainty, owing to the poor preservation of the cheeks; in other regards, however, it seems probable that the restoration attempted cannot be far from the truth. As restored, the skull has a length of about 26 cm. from snout to occiput.

As noted above, the animal is quite surely an eryopsid, or at least a form closely antecedent to this group (unfortunately the nature of the basal articulation of the braincase and palate cannot be determined). It is not an *Eryops* and is certainly a type otherwise unknown in North America. It is possible that it is generically identical with one of the European eryopsids, although these are later in time of occurrence (cf. Romer 1947: 136-139, fig. 23). However, *Actinodon* can be excluded, because of the fact that the large prefrontal present here would presumably block the lacrimal-frontal contact described in that genus; *Osteophorus* has an interfrontal; these two genera and *Sclerocephalus* and *Onchiodon* as well are short-faced, whereas the fragmentary remains of the "face" in this specimen indicate considerable facial elongation. Distinctions from *Chelydosaurus* of the Bohemian Lower Permian are less clear, but differences in both geological and geographical occurrence render identity improbable. I herewith erect the new genus and species *Glaukerpeton avinoffi*, with this skull as the genoholotype; the specific name in honor of the late Director of Carnegie Museum, Dr. Andrey Avinoff, whose encouragement and support aided greatly in the work of gathering this collection. The genus and species may be jointly defined as a rhachitomous amphibian with the characteristics of the Eryopsidae, face relatively long, lacrimal

not in contact with frontal, no interfrontal, sculpture finer than in *Eryops*.

At the same locality as the type were found several other fragments pertaining to a large rhachitome (no. 8591), presumably *Glaukerpeton*; these include a postparietal and other skull scrap and an *Eryops*-like phalanx 14 mm. long.

Much of the tetrapod material from locality C, at Pitcairn, Pennsylvania, is of amphibian nature; certain elements were reasonably compared by Case (1908) with those of *Eryops*. The material is quite surely that of a rhachitomous type and hence of a form comparable in a general way to *Eryops*. It is, however, quite improbable that this typical Permian genus existed as early as the Conemaugh, the horizon from which this material comes. Further, at least one of the specimens shows distinct differences from *Eryops*. It is, on the other hand, not unlikely that the material pertains to *Glaukerpeton*, a rhachitome of appropriate size and geological occurrence.

The presumed *Glaukerpeton* material from Pitcairn includes: (1) a dorsal vertebra, lacking the spine, showing typical rhachitomous structure (Case 1908: 235, fig. 1, pl. LIX, figs. 5, 6) (no. 1944); (2) a proximal caudal neural spine comparable to that of *Eryops* (Case 1908: 235-236, fig. 2) (no. 1948); (3) a distal neural spine of a rhachitome (Case 1908; pl. LIX, fig. 4) (no. 1947); (4) several ribs (Case 1908: 236, fig. 3, pl. LIX, figs. 7, 8) comparable to the posterior dorsal ribs of *Eryops* (no. 1945); (5) several chevrons (Case 1908: 237, fig. 6, pl. LIX, fig. 2) which Case assigned to the Diadectidae are, however, directly comparable with the chevrons of such a rhachitome as *Eryops* and differ from those of diadectids (and other reptiles) in the large size of the intercentrum from which the chevron arises; (6) other fragments of the axial skeleton which are essentially indeterminate; (7) incomplete acetabular regions of the pubis and ischium of an animal comparable generally to *Eryops*; suggested by Case (1908: 238-239) as fragments pertaining to the pelycosaurs or diadectids; the pubic fragment, however, definitely differing from the pubis of these reptilian types and being typically rhachitomous; (8) a bone which Case (1908: 238, fig. 8, pl. LIX, fig. 1) believed to be the ilium of a reptile. It (8) is, however, identifiable as a sacral rib of the general type found in rhachitomes. In his two figures the head of the bone is at the bottom, the distal (ventral) end of the rib blade at the top; figure 8 is a medial, the plate figure a lateral view of the rib. While the general type of

structure is comparable to that of the *Eryops* sacral rib, there is complete difference in detail, much of which may be seen without lengthy description if the present specimen be compared with the *Eryops* sacral figured by Case (1911: fig. 30).

In sum, all the material noted above appears to be compatible with its pertinence to a single rhachitomous amphibian, but one distinct from *Eryops*; tentative assignment to *Glaukerpeton* is reasonable.

Some fragments of a disarticulated rhachitome skeleton from locality 2 (no. 8538), at practically the same horizon as that of locality 1, may also belong to the same amphibian. These include: (1) a few fragments of cranial bone, comparable in sculpture to the type skull; (2) a labyrinthine tooth; (3) several intercentra comparable in size and general appearance to those of *Eryops*; (4) a characteristic pleurocentrum of rhachitomous type; (5) a badly crushed neural arch (the spine is not preserved); (6) a crushed ulna, comparable in size and proportion to that of *Eryops*; (7) ? distal end of a crushed femur; (8) several flattened structures, apparently parts of expanded thoracic ribs; (9) ventral dermal scales. The material, as far as can be told, is comparable to *Eryops*; but on stratigraphic grounds it is improbable that it belongs to that genus, and it agrees well with the generalized rhachitomous structure expected in the present genus and species.

Eryops* cf. *megacephalus

The common large amphibian of the early Permian Texas Redbeds is *Eryops*. This form is also present in beds of similar age in Oklahoma and New Mexico; it is therefore not unexpected that it proves to be the common large amphibian in the Dunkard as well. Remains indistinguishable from the Texas animal are found in a number of localities in both Washington and Greene formations.

Notable is a specimen, no. 8531, from locality 8 (Ryerson Station) in the Washington formation (pl. 2, fig. 6). This consists of the greater part of a skull seen in dorsal view, embedded in some four blocks of hard limestone. The premaxilla is separated by fissure from the remainder of the skull, as is the left quadrate-jugal region, and the major part of the skull is cleaved down the midline into two blocks. There are many imperfections, and sutures are difficult to find, but first-hand comparison with skulls of *Eryops* from Texas shows great similarity even to details such as the contours of individual elements. With due allowance for fissures between the blocks, the length of the skull from snout to quadrate appears to be about $365 \pm$ mm. The

distance from orbit to naris is 125 mm.; if the ratio of this distance to total length were the same as in Texas specimens, the skull length would be about 385 mm. — a figure comparable to the direct estimate of total length above. The skull is thus rather small — at about the minimum in size — for presumably adult Texas *Eryops* skulls from the typical middle Wichita beds of the Belle Plains and Admiral formations (cf. Sawin 1941: 410), but appears to be of approximately the same size as a number of *Eryops* skulls and partial skulls from lower Wichita deposits (Moran and Putnam formations) in the Harvard collections. Found with this skull was a characteristic *Eryops* neural arch lacking the distal portion of the spine, an atlantal neural arch identical with that of *Eryops*, and a cleithrum with a nearly complete stem, but lacking most of the dorsal blade.

From locality 33 were obtained considerable portions of both upper and lower jaws of a large amphibian, indistinguishable from *Eryops*, together with the parasphenoid and much of the sphenethmoid (no. 8536). Of the upper jaw, anterior portions of both maxillae are preserved, together with the posterior end of the left maxilla. Nearly the whole left lower jaw was present, but the posterior portion is not well preserved; in addition there is present the symphyseal region of the right jaw ramus. Of the left jaw, an anterior portion containing the first 25 teeth (and alveoli) measures 13.5 cm. in length, as compared with a measurement of about 18.4 cm. over the same region for the *Eryops* skull figured by Sawin (1941: pl. 5); this suggests a skull length of 320 mm. The characteristic small symphyseal teeth are present on the jaw. As in *Eryops* of Texas the first three "incisors" in the upper jaw are larger than the teeth following them and there is a development of a "canine" region, tooth 13 being the largest of the maxillary series, with the teeth adjacent nearly as large. A single pleurocentrum is present as well as portions of the dermal shoulder girdle elements.

Locality 28 produced several specimens of *Eryops*. One (no. 8532) consists of the central portion of a skull, exhibiting much of the skull table and interorbital region (pl. 2, fig. 1). The posterolateral margins are broken edges, but on the right side and anteriorly the boundaries are along sutural lines. The "cheek" region — squamosal and jugal — had separated from supratemporal and postorbital, and anterior to the orbit prefrontals, nasals and internasal had separated on either side from the frontals. This separation is highly suggestive of immaturity, as is the situation on the ventral surface. Here, much of the braincase, including the sphenethmoid anteriorly, is preserved but considerably

flattened, as if ossification were not far advanced in the cartilage bone elements. The palate had separated at the basal articulation, a further indication of a juvenile condition. The clear outline of the missing interfrontal is proof that the specimen is one of *Eryops*. If measurements of the parts available are compared with similar measurements of complete skulls, the skull length (to the quadrates) can be estimated as about 405 mm.

At this locality, but in matrix of a different color and hence not necessarily associated with the skull material, was found a cleithrum, clavicle and immature scapulocoracoid (no. 8535, pl. 2, fig. 2). The two dermal elements are nearly complete. They are of small size compared with those of Texas specimens — roughly about three-fourths the linear dimensions of typical Wichita elements. In similar matrix is a very immature scapulocoracoid, crushed flat and ossified only in the scapular region to about the extent of an immature Texas specimen figured by Watson (1919: fig. 1). This cleithrum, clavicle and scapulocoracoid are all of the left side and are not improbably from one individual.

Another animal, however, is represented by the right glenoid region of a scapulocoracoid which, in contrast with the other specimens from this locality, is well ossified and mature (no. 8534). While too incomplete to allow of significant measurements, the specimen is definitely smaller than typical Wichita ones.

Also from locality 28 is a jaw fragment (no. 8582) which may belong to one of the specimens above.

From locality 6 (Cameron) came a specimen (no. 8533) including a nearly complete left maxilla and part of the skull roof and palate adjacent to it. The maxilla contains about 30 teeth and alveoli in a length of 14 cm. This indicates a skull length of about 335 mm. — again a low figure.

At locality 19 was found a fragment of a jaw of a large amphibian, apparently *Eryops*; at locality 21, a tooth of labyrinthine type which may belong to *Eryops*; at locality L, the distal end of an expanded rib, with a terminal cup for attachment of a cartilaginous extension; this agrees with thoracic ribs of *Eryops*.

A number of specific names have been given to specimens of *Eryops* from the Redbeds of the Southwest. Distinctions between them are, however, quite uncertain. It is probable that in the Texas beds "vertical" species differences may be eventually determined, and it is

not improbable that eventually specific differences may be found between Texas forms and those from Oklahoma, New Mexico and the Dunkard area. For the time, however, no valid diagnostic character can be cited and it is preferable at present to assign the Dunkard material to the genotypic species *E. megacephalus*. The Dunkard animal, as noted above, is generally smaller in size than specimens from the Admiral and Belle Plains formations, although this may be in some measure due to immaturity of the material. The size range is, however, not incompatible with that of specimens from the lower Wichita formation of Texas.

"Branchiosaurus" darrahi

I have elsewhere (1939) discussed the history of the branchiosaur concept and pointed out that most supposed branchiosaurs are probably immature or larval labyrinthodonts — most commonly eryopsids. Several specimens of the sort are present in collections from this region. The name "*Branchiosaurus*" *darrahi* was given by me to a larval labyrinthodont, presumably of an *Eryops*-like form, from locality F in the Conemaugh formation (Romer, 1939).¹ It is not improbably the larva of *Glaukerpeton*.

In a soft shale at locality 17 were found remains of a small amphibian skeleton (no. 8561). Because of the fragile matrix and the delicate nature of the skeleton, preservation and preparation of the material proved difficult. Of the head there is most of the table and circumorbital region, seen from below. The skull shape was obviously that of the typical "branchiosaur" — short-faced and large-eyed. The specimen might well be a larval *Eryops*. The orbits are about 4 mm. in diameter, the interorbital distance 2 mm.; the table is broad and measures 10 mm. in width. The skull is incomplete posteriorly; its total skull length was presumably on the order of 15 mm. The reverse of the slab carrying the skull shows a clavicle and interclavicle of the general type seen in *Eryops*; the clavicle measures 9 mm. from the base of the ascending process to its distal termination; as preserved, the interclavicle measures about 10 mm. in length, 9 mm. in width. Imperfect remains of limb bones and ribs are present.

Possibly an immature *Eryops* also is a larger "branchiosaur" specimen from locality 6 (no. 8542). This is represented, in addition to a few

¹ I discover to my embarrassment that I had previously (1935: 1635) referred to this specimen as *B. montrosensis*; no description was given and this is hence a *nomen nudum*.

obscure remains, by a partial skull of rhachitomous type, the elements present including postparietals, parietals, frontals, supratemporals, and most of the postorbital series. Unfortunately, the skull becomes imperfect anteriorly not far from the level of the anterior margin of the orbits, so that it is uncertain whether the characteristic interfrontal was present. The oval orbit measures 13 mm. in antero-posterior diameter. The length from the posterior margin of the orbit to the posterior margin of the skull table is 15 mm.; if the face were of "branchiosaur" proportions, the total length would have been about 40 mm.

Undetermined Rhachitomes

Fragmentary remains from a number of Dunkard localities indicate the presence of one or more members of the Rhachitomi of a size considerably smaller than *Eryops*. In Texas, *Trimerorhachis* is the common rhachitome of this order of magnitude. Dunkard remains have been provisionally assigned to this genus by Whipple and Case (1930: 371) and others. But, there is no positive proof of the presence of this Texas form. On the other hand, the material is too fragmentary to warrant, in the absence of clearly distinctive features, the erection of any new genus or genera for its reception.

Much of it consists of vertebral elements. At localities 28 (no. 8568, figs. 2A, B) and M (Tilton 1926: 393) have been found isolated rhachitomous intercentra of the general type seen in *Trimerorhachis*, in which the central portion remained unossified and the element is a slender crescent in end view; a partial intercentrum of the same sort was found at locality 6. At locality 4 was found an articulated series of three vertebrae (no. 8569, pl. 2, figs. 3, 4). These have been so crushed that the ventral surfaces of the intercentra are visible on one side of the small slab containing them; on the other are seen the broken ends of the intercentra, the pleurocentra and the poorly preserved bases of the neural arches. Direct comparison of these vertebral elements with those of *Trimerorhachis* shows differences which render it

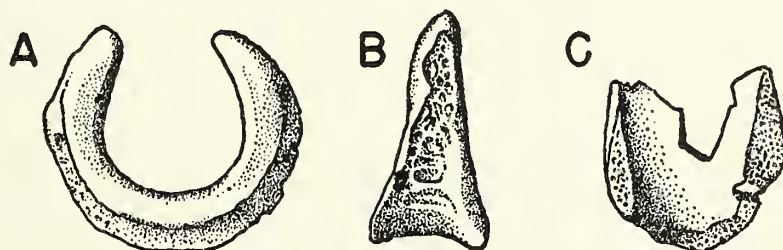


FIG. 2. Small rhachitomous intercentra. A, B, the same specimen in end and side views, no. 8568; C, end view, no. 8575. Natural size.

difficult to identify them generically with that form. There are differences in surface contours and, especially, the Dunkard intercentra are more prominently developed dorsally into a slender pointed termination. These specimens are, however, rather closer to a rhachitome from the lower Wichita formations (Moran, Putnam) of Texas which is as yet undescribed. An intercentrum from locality 6 (no. 8575, in part, fig. 2C) resembles those mentioned above except that a film of ossified bone extends inward to the region of the notochord. Tilton (1926: 391-394, pl. 11, fig. F) described a collection of similar rhachitomous intercentra and an imperfect neural arch from locality J and another intercentrum of this type from locality M (1926: 393, fig. 2); he mentions a caudal vertebra from locality K (1926: 393) which is, however, not described and hence may be of some other nature.

At locality 23 was found a neural arch (no. 8570, fig. 3D) comparable to that of *Eryops* but of much smaller size, although apparently mature. There is no guarantee that this arch belonged to the form or

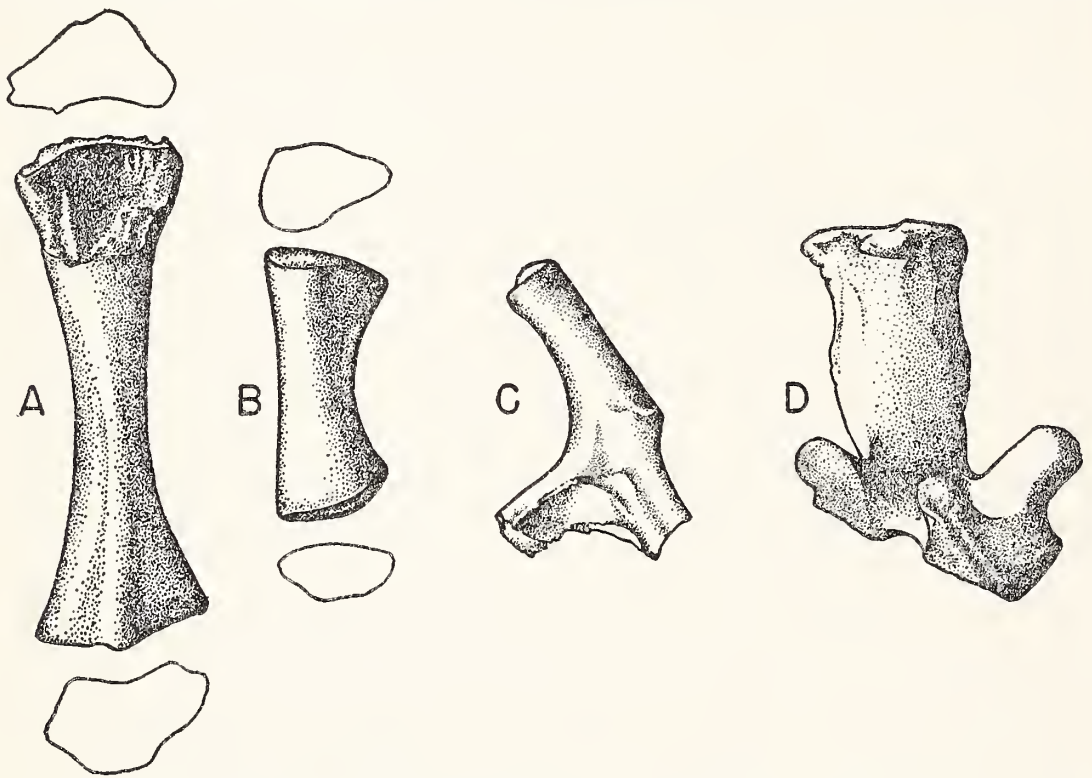


FIG. 3. Remains of small rhachitomes, presumably. A, femur, B (?) tibia, C, ilium, all from locality L (material at Marietta College); D, neural arch, no. 8570. A-C, $\times 4/3$; D, $\times 1$.

forms to which the intercentra just described pertain; it will be noted that the neural arch of *Trimerorhachis* is of a very different character.

From locality 5 was recovered the greater part of a jaw of rhachitomous type (no. 8571), 112 mm. long as incompletely preserved, and

probably 140 mm. long when complete. There is a coarse sculpture, but little detail can be made out. The specimen is of dimensions appropriate to the vertebral material described above. In size, it is comparable to *Trimerorhachis* but there is, in contrast with that genus, a well-developed "coronoid" region which rises well above the general jaw level. A poorly preserved jaw which may be of similar type is present, together with a clavicle and other sculptured bone, at locality 15 (no. 8572), and at locality 37 a small fragment of upper jaw (no. 8613) of appropriate size. Specimen no. 8592 consists of obverse and reverse of the angular and articular regions of a jaw of *Trimerorhachis* size, with a coarse external sculpture. It is probably from locality 1, and hence much earlier in time than the Dunkard specimens described in this section, but the locality record is uncertain.

The material at Marietta College from locality L, tentatively identified as *Trimerorhachis* includes, as well as sculptured plates of uncertain nature, several small limb and girdle bones shown in figure 3 A-C. These may belong to a small rhachitome, but this is not certain.

***Diploceraspis burkei* gen. et sp. nov.**

"Horned" nectridian amphibians are common in the Upper Carboniferous of both Europe and North America, and *Diplocaulus*, a large and long-horned form, appears in the late Pennsylvanian of Illinois and is a common member of the Clear Fork fauna of the Texas Permian. Members of this group of amphibians are common also in the Pittsburgh region; their remains are the most frequently encountered of any animal type and are present in about half of all collecting localities. The history of the group appears, however, to have differed somewhat in this eastern region, with the parallel development of a long-horned type comparable with but distinct from *Diplocaulus*.

Materials of this animal are most common in the Greene formation of the Dunkard. A considerable number of fragments of vertebrae and sculptured bone were found at locality 26; no other tetrapod remains were found at this locality, and hence it is not unreasonable to assume that the *Diplocaulus*-like materials from this site belong to a single form. Locality 26 lies in a limestone presumed to be the middle Rockport limestone of the Greene formation. Stratigraphically close, in the Rockport limestone series, are localities 18, 20, 21, 23, 24, 27, 28, 29, 30, and L, also containing materials of similar character. The description following will be mainly based on the material from

locality 26, but that from the other localities listed will be used to fill in details.

There is no complete skull; the greater part of a skull, seen in dorsal view, is present in no. 8551, but with the "horn" tips missing and the anterior part of the skull destroyed (pl. 2, fig. 5). Specimens 8552 (pl. 1, fig. 8), 8548 and 8553 (the last from locality 28) include nearly complete "horns"; various other skull fragments are present in the material. Almost all specimens are seen in dorsal view (except for distal portions of the "horns"). Using all available data, the skull

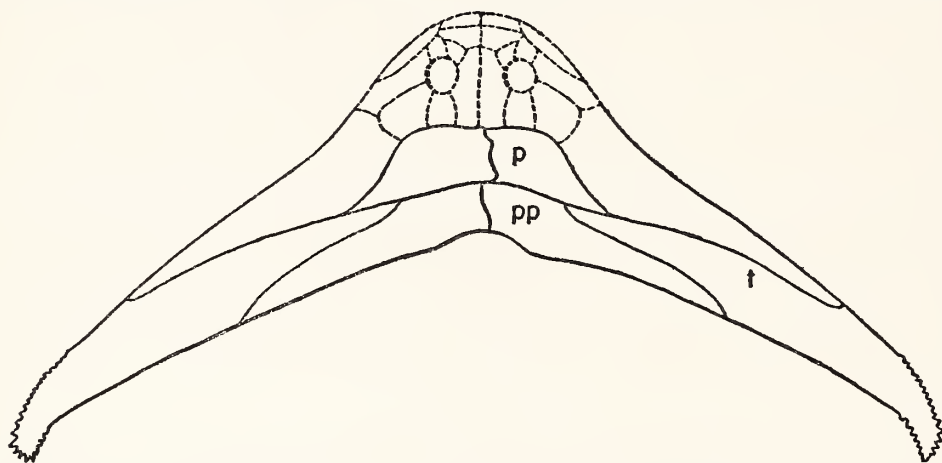


FIG. 4. Attempted restoration of skull of *Diploceraspis burkei*. The central and anterior portions of the skull are entirely hypothetical. One half the size of typical specimens. Abbreviations: *p*, parietal, *pp*, postparietal, *t*, tabular.

may be restored with fair safety on the pattern seen in figure 4. In no specimen is the anterior part of the skull preserved. The animal is obviously of the diplocaulid pattern in skull proportions, with quite long and slender tabular "horns." These are directed more laterally than in typical *Diplocaulus* material; the anterior margins of the two "horns" when prolonged meet at an obtuse angle of about 110°, whereas the typical Texas *Diplocaulus* gives a figure generally well on the acute side of 90°. The back margin of the head shield shows a concave curved rim above the region of the occipital condyles much as in *Diceratosaurus* and *Batrachiderpeton* and in contrast with *Diplocaulus*, which has a smoothly rounded posterior margin. The slender tips of the "horns" are curved and, as shown by no. 8552, bear a series of sharp serrations on the convex margin. There is no positive proof as to the direction of curvature of these tips, but it is reasonable to assume that they curved posteromedially rather than laterally.

The sculpture is in the form of a series of tiny pits which show little of the usual amphibian tendency toward oval elongation, even

when distant from a presumed center of ossification. The average diameter of the pits is on the order of one-half millimeter. This is sculpturing of a much finer sort than in the case of the Texas *Diplocaulus*. It is in part attributable to absolute size differences in the individuals concerned. However, an immature Clear Fork *Diplocaulus* which is of approximately the same size as the present specimens has pitting with an average diameter nearly twice as great as in this material.

Little can be made out as to sutural pattern except that there appear to be, as in *Diplocaulus*, very broad postparietals, extensive tabulars, and broad parietals and supratemporals. No data are present as to palatal structure or braincase, but a well-preserved atlas vertebra (fig. 5C, D) proves the existence of distinct paired occipital condyles, as in *Diplocaulus*.

Specimen no. 8551, when restored, measures about 75 mm. from the mid-point of the posterior margin to "horn" tip. Specimen no. 8552 was apparently slightly larger, on the order of 85 mm. for this measurement, and specimens no. 8548 and no. 8553 were probably of this or a somewhat larger size. Since there is thus a general agreement between specimens, it may be reasonably assumed that we are dealing with "adult" animals. These individuals are far below the typical Texas Clear Fork *Diplocaulus* in size, although in these Redbeds occasional small and presumably young individuals are encountered.

Partial jaws are present in nos. 8552 and 8553. In the former the jaw is visible from the inner surface, with the anterior end incomplete; in no. 8553 an adhering film of limestone makes detailed preparation difficult. The ramus of no. 8553 is 30 mm. in greatest length, that of specimen no. 8552, 26 mm. as (incompletely) preserved. The proportions of the jaw are much as in *Diplocaulus*. The ramus is flattened ventro-laterally and sculptured; it is strongly inturned anteriorly toward the symphysis. Posteriorly the jaw is less flattened and attains a modest height, with a distinct "coronoid process." There is a retroarticular process. On the inner surface there is no indication of a mento-meckelian fenestra, but a broad groove extends antero-posteriorly along this aspect; within this groove the bone shows a spongy surface through which there appear to extend a number of small openings. Sutures were not discovered. The dentition is not completely preserved in either specimen; it appears probable that there were 12-15 fairly large subequal marginal teeth (+alveoli), in contrast with a larger number of tiny teeth in *Diplocaulus*. Individual

teeth where well preserved have a length of about 1.5 mm., and a basal diameter of somewhat less than a millimeter. On one specimen stumps are present of two teeth of good size internal to the marginal tooth row and close to the symphysis. On the other there is some indication of coronoid teeth, but the evidence is not clear.

There are a few postcranial remains. At locality 20 a limestone block exhibited a naturally weathered clavicle, nearly complete (no. 8555). The flattened ventral surface bears a punctate ornament finer than that of the skull roof, with indications of radiation from a center near the base of the ascending process. This surface is sub-triangular, comparable in shape to that of *Diplocaulus*; it measures 19 mm. in anterior-posterior length, 14 mm. in breadth. There is a slender ascending process which as preserved is 8 mm. in length. There are in the collections several other incompletely preserved plates which may be remains of clavicles or interclavicles. There are no further identified remains of girdle or limb elements.

Vertebrae (none, however, articulated) are present at almost all of the Greene localities listed above (fig. 5). Of dorsal vertebrae, eight

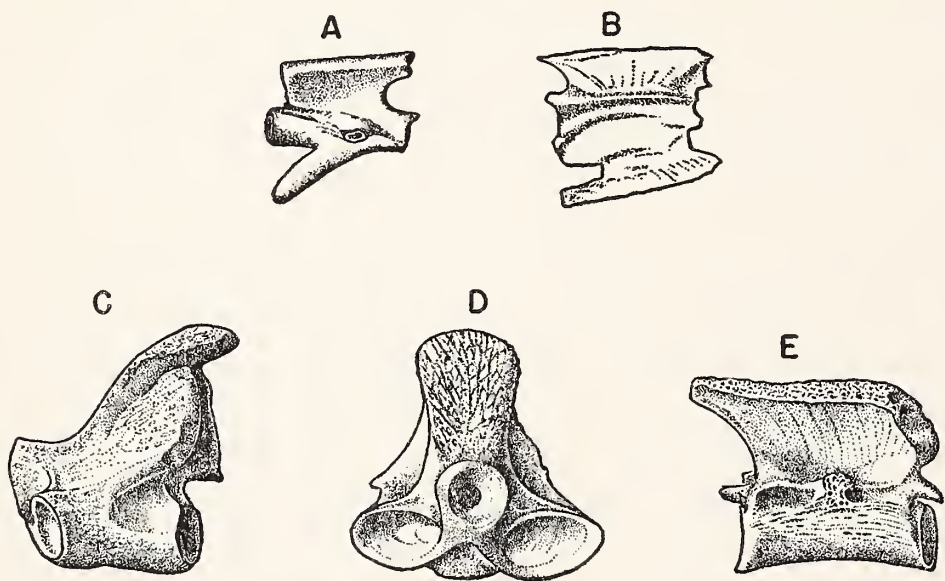


FIG. 5. *Diploceraspis burkei*, vertebrae. A, presumed anterior caudal, no. 8555; B, typical caudal, no. 8550; C, D, "atlas" in left lateral and anterior views, no. 8553; E, typical dorsal, left lateral view, no. 8549. A, B, E, $\times 4/3$; C, D, $\times 2$.

have measurable lengths of 5, 7, 7, 7, 11, 11, 13 and 14 mm. There are, further, four fairly complete caudals, with lengths of 8, 8, 9 and 10 mm. There is thus considerable disparity in length, part of which, at least can be attributed to growth stages and regional differences.¹

¹ Note the great disparity in length along the presacral series of *Diplocaulus* as seen, for example, in fig. 3 of Douthitt (1917).

These measurements are, like those of the skull, far below those of presumably adult Clear Fork *Diplocaulus* specimens. The presacrals show, in general, a typical pattern for this group. The surface of the centrum shows, where well preserved, a somewhat rugose, vermiculate pattern comparable to that of *Diplocaulus*. There is, however, a notable difference. In *Diplocaulus*, the dorsal neural spine develops as an unornamented ridge bearing a characteristic pit. In the present form, the dorsal neural arch is preserved and visible in five instances; in each the arch is strongly sculptured, as it is in *Diceratosaurus* — a sculpturing much more pronounced than the general rugosity of other parts of the vertebra.

Three of the four caudals from the Carnegie Museum localities show a structure quite comparable with those of the proximal half of the *Diplocaulus* tail, and a short series of caudals from locality L, although poorly preserved, is similar. A fourth vertebra in the Carnegie Museum collection from locality 20 (no. 8555) is of unusual character (fig. 5A). It bears a neural arch of "caudal" type and a haemal arch. The haemal, however, instead of being that characteristic of the tail generally, is a rod directed postero-ventrally. It is suggested that this element is a caudal from an immediately postsacral position.¹

It is obvious that in this Dunkard amphibian we have a form related to *Diplocaulus* of the contemporary Texas Redbeds, but notably distinct from it in its neural arch sculpture. This is herewith designated *Diploceraspis burkei*, gen. et sp. nov. with no. 8551 as the genoholotype.² Apart from the feature of neural arch sculpture, distinctive characters which may be either generic or specific include the long and slender "horns" which are directed more laterally than in *Diplocaulus*; the recurved and spiked nature of the horn tips; the delicate sculpture of the dermal roof; the teeth, relatively larger and less numerous than in *Diplocaulus*; and the relatively small size of the animal, typical representatives being somewhat less than one half the size of the "normal" Clear Fork *Diplocaulus*.

As both Jaekel (1903) and Watson (1913) have pointed out, *Diplocaulus* was preceded by and descended from Carboniferous forms with shorter "horns." It is probable that *Diplocaulus* and *Diploceraspis*

¹ Although this does not agree with Case's description of a vertebra of *Diplocaulus* from a presumably similar position (Case 1911: 89).

² The specific name in honor of Mr. John J. Burke, leader of the expeditions on which this material was collected.

have evolved in parallel fashion from distinct Carboniferous ancestors. The presence of sculptured neural arches suggests that the latter genus has descended from *Diceratosaurus*, common in the Upper Pennsylvanian of this very region. *Diplocaulus* (already present in the late Pennsylvanian of Illinois) might have developed from one of the other typical Carboniferous genera — *Cephalerpeton*, for example.

The description of *D. burkei* above was based on material from localities in the Rockport limestone horizons of the Greene group. Remains which may pertain to this form are present at both higher and lower Dunkard levels. In the upper Greene, skull fragments and a dorsal vertebral centrum, 12 mm. in length, were found at locality 35 and a dorsal centrum 8 mm. long at locality 37. Most puzzling are two specimens from locality 36 (no. 8547). Preserved as hollow molds in slabs of limey sandstone are fragments of spines or hornlike structures, one of which is shown in plate 1, figure 6. The structure was much flattened, with a thickness as preserved of about 3 mm. as contrasted with a width of about 1 cm. Both sides bear an ornament closely comparable to that of a *Diploceraspis* horn and one tends to assign these specimens to *D. burkei*. But, as can be seen from the figure, there is very little tapering from one end of the segment preserved to the other. If this is a "horn," it was seemingly one of inordinate length. I have tried to imagine these "spines" as belonging to some other type of animal (or plant) but with little success.

Lower levels in the Dunkard have yielded fragmentary remains of *Diploceraspis*: a sculptured bone fragment, possibly a clavicle, from locality 16; from locality 14, an incomplete stemmed clavicle and a dorsal vertebra 10 mm. long; from locality 13, dorsal vertebrae 10 mm. and 9 mm. in length and a skull fragment; sculptured bone fragments including part of a "horn" from locality 7; and a dorsal vertebra with a length of about 10 mm. at locality 6. This last specimen is perplexing, for it lacks — in contrast with all other dorsals of this species — sculpturing on the neural arch. Are there, perhaps, two diplocaulid types in the Dunkard? The situation is less puzzling when it is noted that there is but a single rib facet present and that, hence, the specimen is from the posterior dorsal region. Caudals, in contrast to typical dorsals, are non-sculptured; a shift occurred at some point anterior to the tail; one or more posterior dorsals might lie distal to the point at which arch sculpture disappeared. There is at present no reason to believe that any of the Washington or lower Greene diplocaulid materials belongs to a form other than *Diploceraspis*.

***Diploceraspis conemaughensis* sp. nov.**

The nectridian material from locality 1 is disappointingly fragmentary. In it are a number of diplocauloid dorsal vertebrae with measurable lengths of 8, 7, 7, 5, 4 and 4 mm. If these are representative, we are dealing with an animal of smaller size than the Dunkard form. The neural arch is seen in four cases; in three it is sculptured (the fourth is presumably a posterior dorsal) and hence suggests *Diploceraspis* of higher horizons or, alternatively, *Diceratosaurus* of the underlying Allegheny group. There are present in the Soho material some eight small slabs (nos. 8544-46) bearing fragments of sculptured amphibian bone with a punctate pattern similar to that of the Dunkard *Diploceraspis* but rather finer and also similar to that of *Diceratosaurus*. I am quite unable to determine the skull pattern from the disarticulated plates present, and the mere presence of a finely punctate sculpture does not guarantee that we are dealing with a *Diploceraspis*. Two specimens are, however, significant. No. 8546 consists of a flattened piece of bone, nearly free of matrix, which is sculptured on both surfaces and represents part of a tabular "horn." It is incomplete at the tip but even so indicates a "horn" development much greater than that of *Diceratosaurus* and nearly as marked as in *Diploceraspis burkei*. The margins of the "horn" are imperfect, but indicate a decrease in width from about 17 mm. to 6 mm. in the length of 3 cm. preserved. This is a slightly stubbier "horn" type than in the Dunkard form, but far closer to it than to *Diceratosaurus*. A fragment belonging to no. 8545 consists of a "horn" tip; this is recurved, but less so than in *D. burkei*, and lacks the prominent spines seen in that form.

Although the material is unfortunately far from adequate and the probable differences from the Dunkard form small, it seems advisable to recognize the Conemaugh diplocaulid as distinct. It is herewith designated as *Diploceraspis conemaughensis* sp. nov., with the "horn" fragment no. 8546 as the holotype, distinguishable at present from *D. burkei* by smaller size, somewhat lesser "horn" attenuation, and a lesser degree of curvature and spinescence at the "horn" tip.

If *Diploceraspis* evolved from *Diceratosaurus* of the Allegheny group, the "horn" attenuation indicated by the Conemaugh material shows a rapid, early evolution of the genus, followed by relative stagnation. The development of *Diploceraspis* paralleled that of *Diplocaulus*. But, while we do not know the skull form of the *Diplocaulus* from the

Pennsylvanian of Illinois, the few known Wichita specimens of *Diplocaulus* are quite "short-horned." The evolution of elongate "horns" may have proceeded more slowly in the *Diplocaulus* line.

***Lysorophus dunkardensis* sp. nov.**

The small worm-like amphibian *Lysorophus* (originally described from the late Pennsylvanian of Illinois) is a common animal in the Clear Fork Permian of Texas (although locally absent in the earlier Wichita beds of that region). It is now recognized that *Cocytinus* and *Molgophis* (including *Pleuroptyx*) of the Allegheny formation of the present region are earlier representatives of this group (Watson 1929: 249; Romer 1930: 81; Steen 1931: 885). It is thus natural to expect that lysorophids would have persisted into the latest Carboniferous and early Permian of the Pittsburgh region. This proves to be true; lysorophids are moderately abundant in the material under study. They are notable, however, for a great range in size and, despite confusion which may be caused by the finding of immature specimens, it appears probable that several distinct forms occur here.

The most "normal" lysorophid is one which appears to be present in a series of half a dozen Dunkard localities and may represent an animal comparable to that of the Texas Permian. It is considerably larger than the characteristic *Lysorophus* of that region, although Olson (1939) has noted the presence there of "outsized" specimens. A well-preserved and maturely ossified centrum from locality 37 (no. 8581) shows a typical lysorophid structure; it measures, however, 9 mm. in length and 8 mm. in end diameter as contrasted with much lower figures generally for the Texas *Lysorophus*. I herewith designate this form as *Lysorophus dunkardensis* sp. nov. with the vertebra mentioned as the holotype; for the time being, its greater size is the only specific character available.

Several other Dunkard specimens may be specifically identical. No. 8584, from locality 34, and no. 8585, from locality 35, consist of vertebral fragments of similar size.

Whipple and Case (1930: 371) report vertebrae similar to those of *Lysorophus* from locality L. This is reasonable, but I did not find such vertebrae in the material available to me. No. 8586 from locality 1 consists of a slab of limestone exhibiting a series of stout curved ribs and an imperfect vertebra resembling those of the species in question.

No. 8587 from locality 3 shows a cluster of similar ribs and sections through vertebrae apparently of a lysorophid nature. If these specimens are correctly assigned, *Lysorophus dunkardensis* is present throughout the series under consideration, from Conemaugh to Greene.

A puzzling specimen from locality 6 (no. 8590) may be mentioned here. This consists of obverse and reverse slabs of shaly clay showing a tangled mass of countless tiny curved ribs and, less clearly, other skeletal remains; all appear to belong to a single animal. These are poorly preserved remains and impressions of vertebrae of lysorophid type, about 4 mm. in length. This specimen is thus intermediate in size between *L. dunkardensis* and a tiny form next described. Are all three growth stages of a single type? As noted below, the small *L. minutus* appears mature, however. In contrast, in the present specimen the vertebral remains are very poorly preserved, despite the well ossified condition of the ribs. Tentatively the specimen may be considered as an immature individual of *L. dunkardensis*.

***Lysorophus minutus* sp. nov.**

In a slab of limestone from locality 30 were found obverse and reverse impressions of much of the skeleton of a tiny elongate snake-like amphibian (no. 8564, pl. 1, fig. 7). A portion of the skull is present and two series of vertebrae: a major series thrown into an S-shaped curve and a second, shorter, series partially overlapped by this. The specimen is crushed and not too well preserved, so that neither in skull nor in backbone have I been able to make out details of structure with any assurance. Of some three types of much elongate lepospondylous amphibians characteristic of the late Paleozoic, the *Ophiderpeton* and *Dolichosoma* groups are eliminated by the fact that the specimen shows quite stout, if short, curved ribs (the articular region is not seen); there is no certain trace of ventral armor. It thus appears likely that the specimen is a member of the *Lysorophus* group, and the general impression one gains of vertebral structure is in agreement with this conclusion. It is, however, of small size compared with the typical Texas form; the centra average somewhat under 2 mm. in length, which is rather less than half the size of the Texas representative of the genus or of the type material from the late Pennsylvanian of Illinois, and still smaller in comparison with *L. dunkardensis*. The size, however, is about that of *Cocytinus gyronoides* of the Allegheny formation of the present region — a predecessor and presumed ancestor

of *Lysorophus*. Since the specimen is well ossified, it is difficult to consider it as an immature *L. dunkardensis*. It is herewith designated as *L. minutus*, sp. nov., with its small size as the only specific criterion known at present.

***Megamolgophis agostinii* gen. et sp. nov.**

This giant lysorophid is the most striking of Permian novelties in the present material. In the Allegheny Group of the Pennsylvanian in this same region, there were present not only the small lysorophid *Cocytinus* but also a considerably larger form, *Molgophis*.¹ The *Molgophis* line continued into the Permian of the region to end with the form here described as *Megamolgophis* — an animal quite unknown in other Permian deposits.

The two most important specimens are nos. 8583 and 8614, the former from locality 28 consisting, in the main, of 27 isolated but well preserved vertebrae, the latter, from locality 11, including the partially articulated remains of what appears to be a single individual (fig. 6), with about 70 vertebrae present. Although most of the materials of these two finds belong to *Megamolgophis*, there is some admixture of other forms; scraps of *Eryops* are found in both, and pieces of sculptured *Diplocaulus* bone in no. 8583. Less important specimens which appear to belong to this snake-like amphibian include a rib-head from locality 35 (no. 8588), a natural mold of a vertebra from locality 36 (no. 8589), poorly preserved vertebrae from locality L which were tentatively referred to *Theropleura* by Whipple and Case (1930) and, doubtfully, a weathered vertebra from locality 1 (no. 8610).

This was an animal of considerable size. The mean length of sample vertebrae from the two major specimens, measured along the ventral surface, is approximately 15 mm. We do not know the number of vertebrae, but Steen cites a specimen of the related *Cocytinus*, apparently complete, with 81 vertebrae. If the count were here the same, the length (adding an allowance for the head) would be about 130 cm., or well over four feet. This is a figure quite in contrast with the length of but a few inches of *Cocytinus* or *Lysorophus*. The length

¹ This genus and a second, *Pleuroptyx*, were described by Cope on the basis of vertebrae. The writer (1930: 106-108) noted that the two appeared to be identical and suggested that these vertebrae pertained to the labyrinthodont *Colosteus*. Steen (1931: 882-885) correctly pointed out that this was not the case, and that the *Pleuroptyx* vertebrae were of lysorophid type. She did not, however, mention *Molgophis* (except for the small "species" *M. wheatleyi* which is a *Cocytinus*).



FIG. 6. *Megamolgophis agostinii*. Part of a specimen presumably of one individual, showing numerous characteristic vertebrae, ribs, partial jaw, etc. No. 8614. $\times 1/3$.

is about that of the common American blacksnake; however, the girth (as noted later) was considerably greater and comparison with a Florida diamondback rattlesnake might perhaps be more apt. Vertebrae of two Allegheny specimens of *Molgophis* approximate the present form in size, but these are exceptional; six specimens give a mean vertebral length of approximately 10 mm. for that genus.

In the vertebrae (fig. 7), the centrum is suturally separate from the neural arch in all cases seen; the union between them was a loose one, and they disarticulate readily. There is no trace of intercentra and the fit between adjacent centra is such that these elements were surely absent. The centra have an appearance superficially like those of many primitive reptiles. They are essentially spool-shaped structures, deeply amphicoelous and notochordal, with an end diameter which is on the average about 85 per cent of the length. In almost every well-preserved centrum the posterior rim bears, high up on the lateral margin, a distinct projecting flange, facing posteriorly, to receive the capitulum of the rib of the following vertebra. Dorsally, there is a longitudinal groove, deepest at mid-length, which lies in the floor of the neural canal. On either side is a broad oblong surface for articulation with the neural arch. This generally occupies the anterior two-thirds of the length of the centrum, facing upward and slightly outward; it is usually nearly flat, but turns slightly upward posteriorly.

The basic pattern of the centrum in *Lysorophus*, *Cocytinus* and *Molgophis*, as described by Sollas (1920), Schwarz (1908) and others, is that of an hourglass or spool surrounding the notochord, from which project (in addition to the arch bases) a pair of lateral longitudinal ridges and a ventral ridge which exhibits to some degree a duplex nature. In *Megamolgophis* we see a strong tendency for elaboration of this pattern of longitudinal ridges, particularly in the ventral ridge system. In a fair proportion of the vertebrae preserved, the construction is relatively simple, consisting of a pair of apposed but distinct ventral ridges and a pair of lateral ridges, with a deep pocket on either side between ventral and lateral elements (fig. 7D). In most vertebrae the lateral pocket is retained but the ventral ridge system is more complex. A median ridge, single or double, may appear between the elements of the ventral pair, or each ventral ridge may be present in double form (fig. 7E). In a stage of greater complexity, the lower aspect of the centrum, between the lateral pockets, becomes a continuous surface in which 8 or 10 ridges may be imperfectly distinguished (fig. 7F).

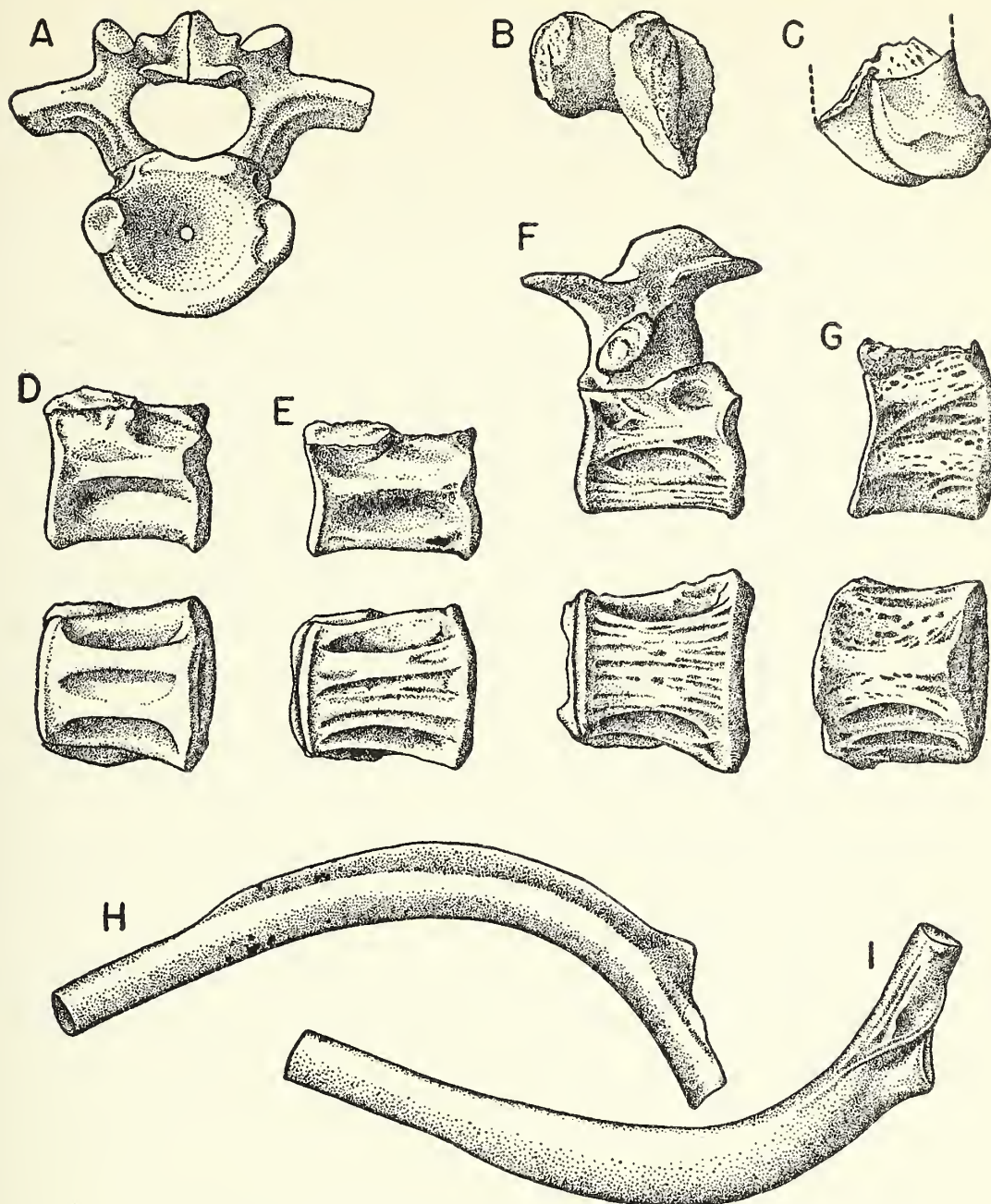


FIG. 7. *Megamolgophis agostinii*. A, posterior view of a vertebra; composite, arches and centrum not definitely associated. B, C, ventral and lateral views of an incomplete quadrate. D-G, left lateral and ventral views of vertebral centra, to show degrees of complexity of development of ridge system of centrum. F is lateral view of the same vertebra shown in A. H-I, internal and external views of a rib of the left side (composite of two specimens). B, C, no. 8614; others no. 8583. Natural size.

A final stage (represented by 4 vertebrae of 27 in specimen no. 8583) is one in which even the lateral pockets and the lateral ridges lose their individuality and the entire outer surface of the "spool," from one arch attachment to the other, shows a considerable series of low longitudinal ridges between which there seldom develop grooves of any depth (fig. 7G). These last vertebrae are relatively short and stout,

with a mean length of 12.7 mm. and a mean diameter of 15.2 mm.; this in strong contrast with general lengths on the order of 15 mm. and diameters of about 13 mm. In these short vertebrae the surfaces for arch attachment extend nearly the length of the centrum; there is a variable development of a forward projecting ventral "lip;" in two of the four centra of this type in no. 8583 there is no development of a facet for the capitulum.

There is nothing to indicate the position in the articulated column of the types of centra described. The last type mentioned is not improbably that of the anterior cervical region, and it may be that there was a progressive simplification of the ridge system along the "trunk" and tail; but, on the other hand, the short vertebrae might possibly be those of the sacral and proximal caudal region.

In a long-tailed animal we would expect a gradual tapering of the centra in diameter and, to a lesser degree, in length, in the distal caudal region. But, among the numerous vertebrae in no. 8614 there is none which appears to be markedly smaller than the average, and in no. 8583 only one notably small centrum; this (somewhat imperfect) has a length of about 13 mm. but a diameter of only about 11 mm. It may be that in both specimens the distal portion of the tail was lost, but quite possibly the tail remained stout to a point near its termination.

Neural arches, many articulated, are numerous in no. 8614, but are poorly preserved. In no. 8583, upward of a dozen arches are well preserved, but are disarticulated. They show an essentially uniform pattern (fig. 7A, F). As in *Lysorophus* the members of each pair of arches are separated; presumably they were connected in life by an intervening plate of cartilage. The stout arch pedicel rises upward with little change in thickness to the level of the zygapophyses. Here, the inner surface curves medially to form the roof of the neural canal. Each arch carries anteriorly on its outer surface a well-developed transverse process, extending outward and somewhat forward from the general level of the arch to a distance of 5-8 mm. and terminating in an oval surface for articulation with the rib tubercle. A system of low ridges may extend on to the arch from the base of the transverse process, and in two of the arches preserved, a stout ridge, bearing a presumed continuation of the articular face, runs anteroventrally in the direction of the capitular articulation on the adjacent vertebra.

The anterior zygapophyses are elongate anteroposteriorly and concave in transverse section, extending forward from a point above the base of

the transverse processes. The posterior zygapophyses are correspondingly elongate and convex in section and extend far posteriorly. Above the posterior zygapophysis each neural arch rises, thinning above, into a low "spine" with a curved upper margin. The entire inner surface of this area is flattened for apposition to the arch of the opposite side. The arches as a whole are closely comparable to those of *Lysorophus*.

A large number of ribs are present in no. 8614, but they are poorly preserved; in no. 8583 none of the ribs is complete, but there are numerous well-preserved fragments (fig. 7H, I). The rib-heads show distinct, subcircular capitula and tubercula; the capitulum does not show the subdivision figured by Sollas (1920, fig. 41, i) in *Lysorophus* or Schwarz (1908, fig. 11) in *Molgophis*. A main rib axis, subcircular in section, extends from the capitulum along the lower margin of the strongly curved proximal portion of the rib. As in many early tetrapods a thin flange extends backward externally from the main shaft of the rib, giving the rib, in section, a figure like that of a musical half note (cf. Sollas 1920, fig. 44, section 86). This flange commences proximally at the tubercle and extends in some instances, at least, about three-fourths the distance from the tubercle to the rib termination, gradually merging into the rib shaft distally. In most of the rib fragments available, the flange is narrow, extending but three or four millimeters beyond a rib axis of about the same diameter. In one rib fragment, however, the flange is about twice as broad, the total breadth of the rib reaching 11 mm.; this gives a configuration resembling that in *Pleuroptyx*. Presumably the variations are regional; possibly, as in more normally built tetrapods, the broader ribs lay in the region adjacent to the shoulder.

A second flange seen in the proximal portion of various specimens of the *Megamolgophis* rib, is, as far as I am aware, a unique feature. This extends anteriorly from the shaft. It is much shorter than the posterior flange; it rises abruptly at a point just proximal to the tubercle, reaches a maximum development of about four millimeters opposite the tubercle, and sinks into the general level of the shaft three centimeters or so distal to that point.

The distal part of the rib shaft is subcircular in section and nearly straight; in several instances where the distal end is preserved, it is seen to be cupped, presumably for the attachment of a cartilaginous ventral rib segment. In the absence of complete and articulated material, no accuracy can be attained in the matter of rib articulation; it appears probable, however, that the width of the body between the

farthest lateral extension of the ribs was not far from ten centimeters. The height from the ventral ends of an ossified rib to the top of the neural arch was approximately six centimeters. Three centimeters or so should be allowed for the curvature of the belly; a subcircular body section is indicated.

There are no articulated limb materials, but several bones appear to be limb elements: for example, a bone in no. 8614 has the appearance of a femur, with a length of 38 mm.; a short stout bone, 30 mm. in length is suggestive of a tibia in no. 8583. It seems certain that, as in *Lysorophus*, the limbs were extremely small.

Specimen no. 8614 includes the articular portion of a quadrate (fig. 7B, C), showing two highly developed articular keels, each curved to about 180° and separated by a deep groove. Further skull material is interesting but confusing. This consists of a mass of crushed and broken material forming part of no. 8614. It exhibits on one surface sculptured dermal bones, obviously part of a skull roof (fig. 8A), and on the other aspect various bony materials presumably cranial in nature, including an incomplete maxilla and fragments which appear to be part of a dentary.

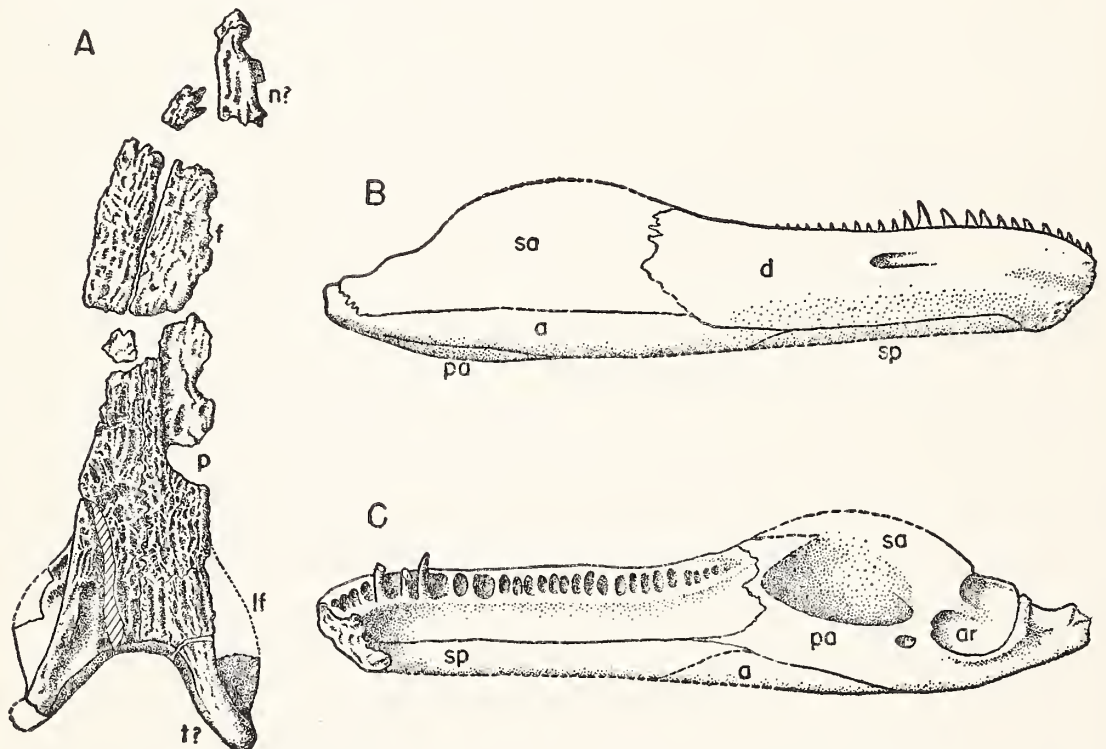


FIG. 8. *Megamolgophis agostinii*. A, remains of skull roof; the outlines of the shelf lateral to the skull table are restored. B, C, attempted restoration of the jaw, outer and inner views. The length in the region of angular and surangular is uncertain. No. 8614. Abbreviations: a, angular; ar, articular; d, dentary; f, frontal; lf, lateral flange; n, nasal; p, parietal; pa, pre-articular; sa, surangular; sp, splenial; t, tabular. $\times 1/2$.

The skull roof materials include, anteriorly, a pair of elements, each about 30 mm. in length and 10 mm. in breadth, which are reasonably identified as frontals; anterior to them are fragments which may represent nasals. Posterior to the presumed frontals is an elongate mass of sculptured bone clearly traversed for most of its length by a zig-zag median longitudinal suture. I interpret the major part of this structure as consisting of a pair of elongate parietals. A tiny pit may possibly be a parietal foramen. Posteriorly, the sculptured surface ceases abruptly at a vertical flange, presumably the upper margin of the occipital surface; on either side of the mid-line, the posterior margin curves backward to terminate in a pointed projection comparable to a labyrinthodont tabular "horn." Sutures are not clear in the posterior portion of this skull table. The sculpture pattern suggests that this region contained a series of postparietal elements. It is reasonable to assume that tabular elements constitute the pair of "horns." Whether the median part of the posterior margin included a pair of postparietals in the more usual pattern of Paleozoic amphibians or a single element, as in *Lysorophus*, is uncertain. I could find no clear sutures on the occipital aspect.

Anterior to the "horns," the lateral margins of the skull roof mass are, as far as preserved, distinct and nearly straight, obviously without any close sutural union in life with adjacent elements. A unique feature is the development on either side of a broad flange of bone extending outward from the table at a level considerably below the sculptured surface. This flange commences posteriorly at the tabular "horn," becomes at once prominent, and runs forward to about mid-length of the parietals. It is not completely preserved on either side, but the parts remaining enable one to restore its outlines, as in the figure, with some confidence.

This skull roof differs notably from that of *Lysorophus* in two features: the sculpture and the sharp occipital boundary. It is, of course, possible that its association with the other material is accidental and that it does not belong to the genus here described. But such an assumption does not greatly help the situation. Apart from a resemblance to *Ophiderpeton* (cf. Steen 1931: pl. V, fig. 2), a form quite unknown in the Permian, this skull roof does not resemble that of any other known amphibian. However, the presence of sculpture, in contrast with the *Lysorophus* condition, may perhaps be correlated with increased size, and the skull appears to have been of proportions appropriate to the jaw material described below. Further, the most

peculiar feature, the free lateral margin of the table and the underlying flange, is readily interpretable by reference to *Lysorophus*. In that animal the cheek region consists only of the elements of the jaw suspensorium, the upper element of which — variously termed “supratemporal” or “squamosal” — was braced against the side of the table. The prominent elongate groove formed here between the flange and the overlying table margin would have been a most effective bracing device to receive the broad head of the “supratemporal.”

Some of the bone on the under surface of the mass which includes the roofing bones is not interpretable. Anteriorly, however, there are incomplete remains of a bone which appears to be a maxilla. A series of alveoli and a few teeth can be made out along the presumed lower margin. Half-way along the portion preserved, the bone is greatly thickened and appears to have carried, here, two or three exceptionally large teeth — the development of a “canine” region, seen in various Permian amphibians and reptiles. Above this thickened area is a dorsal extension of the maxilla, somewhat fan-shaped as preserved, and roughly comparable to processes seen in the “canine” region in pelycosaurs (for example).

Lower jaw material (fig. 8B, C) is present in both major specimens. No. 8583 includes the posterior three-fifths of the right dentary and two fragments (including the symphyseal region) of the left. No. 8614 includes, in three pieces, what appears to be a nearly complete right ramus, but this is badly disarticulated, crushed and eroded. Between the two specimens the dentary is nearly completely known. (The bone in no. 8583 appears at first glance to be larger but the seeming discrepancy is, in the main, due to differences in preservation.) The dentary composed most, if not all, of the symphysis. The outer surface is smooth, without sculpture; at about half length there is a large mental foramen. Posterodorsally, zig-zag rugosities suggest an overlapping suture with the surangular externally; the posterior border is incomplete. There is a vertical inner surface which gives no indication of the presence of coronoids. The external and internal lamina of the dentary are widely separated ventrally, indicating the presence in life of a splenial or splenials to complete the ventral aspect of the jaw ramus. About 30 teeth are present in a distance of approximately 80 mm. At their bases the teeth appear to have been essentially circular in section; toward the apices the few that are well preserved are mediolaterally compressed.

The posterior portion of the jaw is present only in no. 8614. There is a deeply incised articular surface, divided into two portions. This is broadly exposed on the inner surface if (as in the figure) the jaw is laid flat on its outer side; presumably in life it lay in an essentially horizontal plane, the jaw sloping strongly inward ventrally. There is a very highly developed retroarticular process.

A mass of badly crushed and broken bone appears to include the intermediate region of the jaw. I have restored this region, but am none too sure of the structure here, or of its extent; the jaw may have been one to three centimeters longer than figured. The outer surface appears to show a low angular and a more highly developed surangular. On the presumed medial surface a flat bone with a curved margin appears to be a prearticular bounding a typical Meckelian fossa.

Despite many unfortunate gaps in our knowledge, it is obvious that this large snake-like amphibian is a new and very distinctive type, readily distinguishable in various features from even such a related form as *Lysorophus*. It may be formally designated as *Megamolgophis agostinii*, gen. et sp. nov., with combined generic and specific characters as follows: a large lysorophid in which the longitudinal ridge-system of the vertebral centra is more complex than in other known genera — the ventral ridge at the least distinctly double, regionally a development of a considerable series of closely appressed lamellae covering the entire external surface of that element; dermal roofing bones of the skull sculptured; dentary with approximately 30 teeth. Holotype of *M. agostinii*, no. 8583, is from locality 28. The specific name is in honor of Mr. Charles Agostini, preparator on the Carnegie Museum staff who took a major part in the work of collecting the Dunkard material.

Desmatodon hollandi

This genus and species of reptile was founded on a jaw fragment from locality C in the Conemaugh (Case 1908: 236-237, figs. 4, 5C, pl. 59, fig. 1; no. 1938). Four teeth are present and the root of a fifth. As Case noted, the cuspidate teeth resemble those of the Permian cotylosaur *Diadectes*, but are rather more primitive in nature. Since cuspidate teeth are present in several other groups of Permo-Carboniferous reptiles, the present writer had not felt certain, on the basis of existing figures and description, that this form was a diadectid. However, study of the original material and comparison with teeth of *Diadectes* fully justifies Case's conclusion. The tooth figured by Case is the least developed of the four present; the other members of the

series are rather more clearly diadectid in character (pl. 1, fig. 3).

Diadectid "molar" teeth show a pattern reversed in upper and lower jaws; in the upper teeth the major cusp is lateral in position, in the lower teeth, medial. Since Case refers to the major cusp in *Desmatodon* as lateral, it is obvious that he considered the specimen as pertaining to the upper jaw. Although this is uncertain (not improbably the specimen is the anterior portion of the tooth battery of the left dentary), we retain his orientation. In *Diadectes* the inner portion of an upper tooth is greatly expanded, and a secondary cusp is there developed, between which and the primary cusp a wearing surface arises (fig. 9). In *Desmatodon* the secondary cusp is not present as

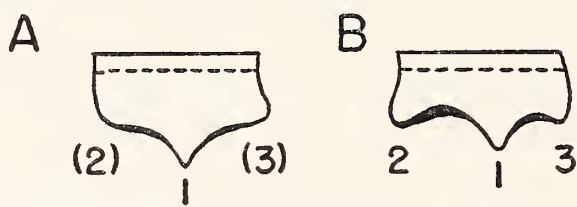


FIG. 9. Outlines of "molar" teeth in anterior view, outer margin to right; in *A*, *Desmatodon*, and *B*, *Diadectes*, to show cusp development. 1, 2, 3=primary, secondary and tertiary cusps of *Diadectes*; (2), (3)=incipient cusps of *Desmatodon*; thickened lines=areas of wear.

such, but there is a highly developed medial swelling (more pronounced on other teeth than on that illustrated by Case) and in two of the four teeth there is here a small area of wear. In *Diadectes* upper "molars" there is also present a tertiary lateral cusp and a smaller, secondary area of wear between it and the principal cusp. In *Desmatodon* this region is somewhat developed although lacking a formed cusp, and one of the four teeth shows wear here. The *Desmatodon* teeth thus appear to be built on the fundamental *Diadectes* pattern, but are far more archaic than in *Diadectes*; the most highly developed *Desmatodon* teeth are comparable to the least developed molars of *Diadectes*—those at the front or back ends of the "molar" batteries. *Desmatodon* may well be, as its stratigraphic position suggests, a direct ancestor of *Diadectes*. Measurement of the linear spacing of the teeth in the *Desmatodon* type gives a figure which is the same as that seen in a specimen of *Diadectes* in the Harvard collections (no. 1743) from a low horizon in the Wichita group of Texas. This specimen is unusually small for a member of that genus and has but about three-fourths the linear dimensions of such an individual as the mounted specimen in the American Museum of Natural History (Case 1910, fig. 5). Small size might reasonably be expected if *Desmatodon* is an ancestral form.

It is possible that a few fragments of bones of diadectid appearance from the vertebrate bonebed at Danville, Illinois, and of the same general late Pennsylvanian age may pertain to *Desmatodon*.

Case suggested that certain other remains from Pitcairn were also of diadectid nature. As noted elsewhere, they are, however, probably amphibian.

I note here a specimen, likewise from the Conemaugh (locality 1), which consists of a series of "cheek" teeth, possibly of the left dentary, of a tiny and seemingly primitive diadectid (no. 8567, pl. 1, fig. 4). They form a battery of transversely elongated teeth set in an oval bony rim similar to that which in *Diadectes* surrounds the cheek tooth series. Five teeth are well preserved, except for their tips; stumps of three others are present; the total battery of cheek teeth appears to have consisted of 8 members, contained in a length of 11 mm. The nature of the tooth arrangement together with their transverse elongation strongly indicates that these teeth pertain to a diadectid. There is, however, but a single sharp cusp on each tooth, this at the presumed outer margin. The specimen was contained in obverse and reverse slabs of shaly limestone; the cusp tips had been broken off when the piece was split, and embedded in the reverse slab. By careful preparation one of these tips was freed and glued in position. The cusp tips were turned sharply outward; externally, the tooth falls vertically from the cusp tip to tooth base and shows a worn surface. An arched ridge curves medially along the tooth from the cusp tip to descend at the inner extremity of each tooth. On three of the teeth there appears to be evidence of wear part way along this ridge.

This tooth pattern, with but a single cusp and no cusp or "shoulder" lateral to it, is more primitive than in any described diadectid. It is possible that this fragment represents a small and primitive diadectid otherwise unknown. I hesitate, however, to formally describe it on the basis of this single specimen. Further, it is not impossible that it pertains to a young *Desmatodon* with some sort of "milk dentition." The teeth in this specimen can be compared to the "summit" portions of *Desmatodon* teeth, with the basal region undeveloped. Provisionally I assign the specimen, with considerable doubt, to that form.

"*Pareiasauroides*"

A cast-like structure found at locality E in the Conemaugh formation was referred to Case (1917), who compared its general proportions with those of the radii of pareiasaurs of the South African Permian but did

not further commit himself. White (1917) designated it as *Pareiasaurus ? henneni* (a name later changed to *Pareiasauroides henneni* Lull 1924). This terminology is unwarranted, for there is no evidence that this specimen is of organic nature; and very certainly it is no pareiasaur (Romer 1935: 1635).

***Limnosceloides dunkardensis* gen. et sp. nov.**

The U. S. National Museum collections contain a partial skeleton of a cotylosaur of moderate size (no. 12166) which was collected by Boyd C. Baker five miles southwest of Cottageville, Jackson Co., West Virginia. This area lies in the Dunkard group, but the horizon is uncertain. Except for a fragment which may possibly include a broken section of an oval tooth, all identifiable elements are from the posterior part of the body, the material including vertebrae, pelvic fragments, and much of the hind legs (figs. 10-12).

Of vertebrae, there is a centrum which may be from the anterior dorsal region. There are, further, 16 vertebrae from the posterior portion of the column. These include: a series of four articulated lumbar; a fifth lumbar which may have been next in succession; a first sacral which was articulated with the last mentioned; five proximal caudals which are not articulated with the sacral; remains of five distal caudals. The upper portions of most of the vertebrae have been weathered off, in most cases shortly above the level of the zygapophyses. Intercentra of small size appear to have been present in the lumbar and proximal caudals and are preserved in three instances; the base of a chevron is seen between one pair of distal caudals.

The vertebrae are characteristically cotylosaurian, and except for size are, for the most part, not readily distinguishable from those of *Limnoscelis* and *Labidosaurus*. Although the neural spines are missing in the lumbar vertebrae, enough of the arches are present to show their "swollen" nature, with zygapophyses placed far out laterally, the zygapophysial surfaces in a horizontal plane and marked with concentric lines. The lumbar show rib facets, diminishing in size posteriorly, at the base of each neural arch, below the projecting buttress of the anterior zygapophyses; the first sacral has a two-faced articular surface of enormous size, on the arch and the adjacent region of the centrum, for a sacral rib. In the proximal caudals, bases of ribs are preserved, attached to the vertebrae. The ribs have conjoined heads articulating with a short transverse process of the neural arch and with a raised area, below and in front of this point, on the

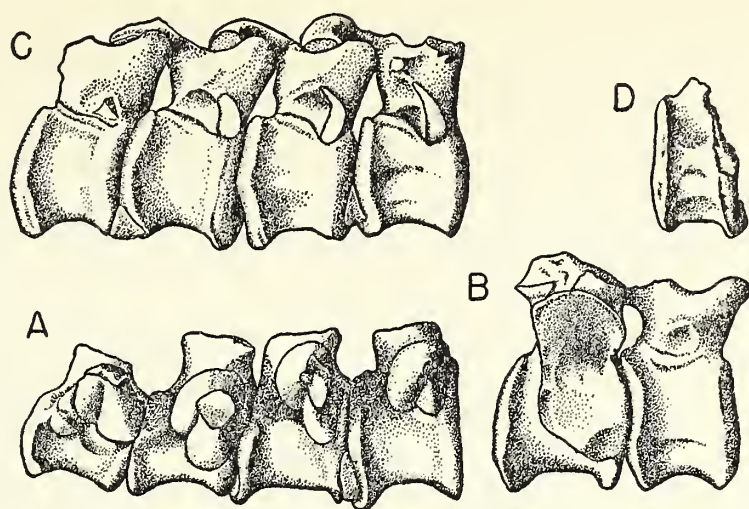


FIG. 10. Vertebrae of *Limnosceloides*, seen from the right side. *A*, proximal caudals; *B*, first sacral and last lumbar; *C*, series of lumbar and posterior dorsals; *D*, incomplete anterior dorsal. $\times 1/2$.

centrum. It is obvious that the small lumbar ribs and the large first sacral rib were not fused with their vertebrae; in the proximal caudals, the tuberculum is fused with the arch, but the capitulum is apparently suturally separate from the centrum. In the lumbar, neural arch and centrum are suturally distinct; in the sacral and caudals, fusion has occurred.

Measurements of the centra are as follows, the two measurements (in mm.) given for each element being lengths taken along the lateral surface and widths across the posterior edge: dorsal, 16, 26; presacral 5, 19, 23; presacral 4, 18, 24; presacral 3, 19, 24; presacral 2, 19, 25; presacral 1, 19, 25; sacral 1, 21, 26; caudal 1 (?), 19, 24; caudal 2 (?), 18, 21; caudal 3(?), 18, 21; caudal 4(?), 18, 20. Of the pelvis, the pubis and part of the acetabular region are preserved on the left side; the latter region is well preserved on the right. Unfortunately, the iliac blade,

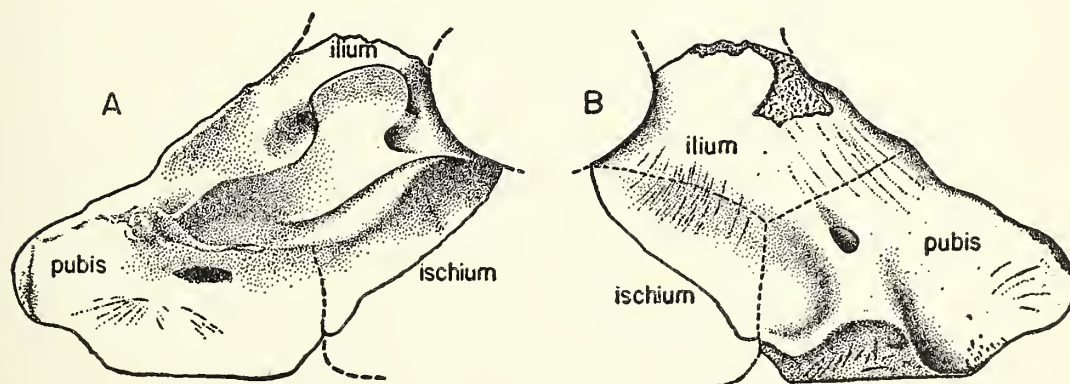


FIG. 11. *Limnosceloides*, incomplete pelvis, external and internal views of left side (partially restored from right). $\times 1/2$.

potentially diagnostic, is not preserved. The construction is that of a captorhinomorph. The pubis is built in a fashion comparable to that in *Labidosaurus* and *Limnoscelis*. As in both these genera, the pubis has a thickened dorsal forward projection, below which the margin of the bone retreats posteromedially toward the symphysis. The pubis in proper articulation turns broadly outward dorsally, so that the external surface in life faces as much ventrally as laterally; the dorsal surface (for pubo-ischio-femoralis internus) does not, however, face as much anteriorly as in diadectids or typical rhachitomes. As in *Labidosaurus* and *Limnoscelis*, the major area of the pubic symphysis lies at the lower end of a thickened internal ridge and is sharply demarcated from thinner symphyseal regions lying more anteriorly and posteriorly. The inner opening of the obturator foramen pierces the upper end of this thickened ridge, rather than lying anterior to it as in *Labidosaurus*.

The right femur is preserved, but is somewhat crushed and imperfect distally, and the crest which bore the internal and fourth trochanters has been broken off; the length can be estimated as very close to 100 mm. A fragment of the proximal end of the left femur is also preserved. The bone exhibits general cotylosaurian and captorhinomorph features and in correlation with the animal's size is stockily built. It is obvious that the missing trochanteric crest was very strongly developed, but the contours of its base indicate that it did not flare widely anteriorly as do those of both *Labidosaurus* and *Limnoscelis*. The distal portion of the ventral ridge system is low but sharply defined and slants posteriorly to the posteroventral margin of the posterior condyle; the ridge is paralleled anteriorly by a longitudinal groove. Although the bone is imperfect distally, its contours make it improbable that the excavation of the side of the posterior condyle, prominent in both *Labidosaurus* and *Limnoscelis*, was developed to any degree here. The ventral popliteal surface is deeply excavated adjacent to the anterior condyle. On the head of the bone a distinct ridge is developed dorsally from the area which I believe to have carried the pubo-ischio-femoralis internus attachment. Both the femur and tibia are incompletely ossified at the ends; whether this is a feature of the species or indicates a juvenile condition cannot, of course, be said. The right tibia is nearly complete, with a length of 72 mm., but is somewhat weathered and crushed; the head of the left tibia is present in a better state of preservation. The bone does not differ notably from the sturdy tibiae of other cotylosaurs. The ridge

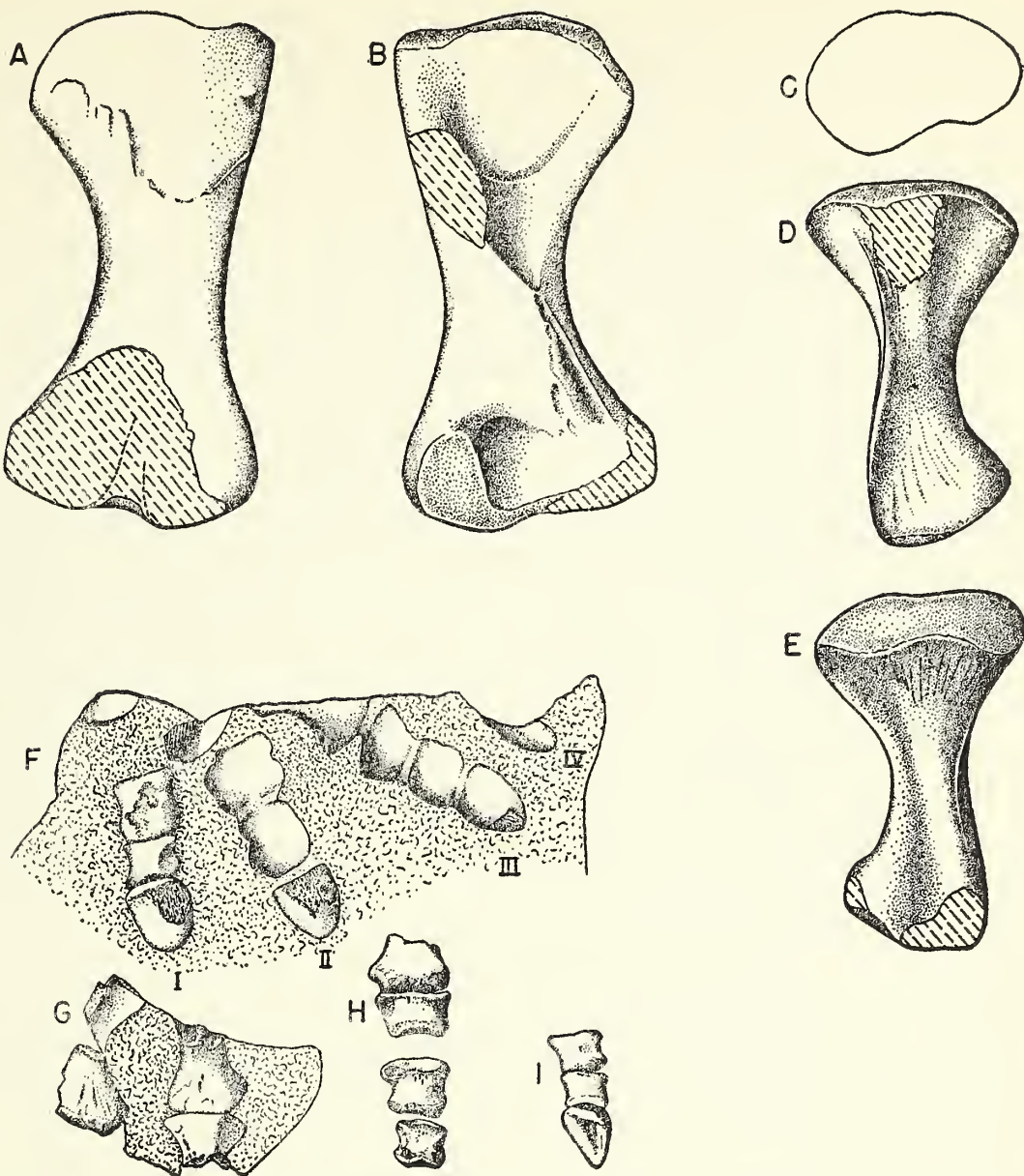


FIG. 12. *Limnosceloides*. A, B, femur in dorsal and ventral views. C-E, tibia, outline of proximal end, extensor surface and flexor surface. F-I, material of pes. F, part of left foot, in sandstone block; part represented by impressions only. G, ventral surface of two metatarsals and a phalanx of right foot (?) in small sandstone block. H, articulated end of metatarsal and two further non-associated phalanges of right foot (?). I, articulated phalanges of (?) fifth digit. $\times 1/2$.

separating extensor and flexor surfaces medially is sharply developed and extends well proximally, medial to the cnemial crest.

Considerable portions of the left pes are preserved as impressions or weathered bone in a sandstone slab, and a number of other fragments most, at least, from the right foot, are also present (fig. 12 F-I). These suggest a typical cotylosaur foot, nearly as stoutly built as that of *Limnoscelis*.

As seen from the above description, we are dealing with a captorhino-

morph cotylosaur intermediate in size between *Labidosaurus* and *Limnoscelis*, the latter being the largest member of the group known at present. In general the linear measurements of this animal are about half again as great as those of *Labidosaurus* of Texas; *Limnoscelis*, again was about 50 per cent larger than the present form which (assuming the usual presence of a long tail) might have had a total length of about 145 cm., or somewhat under 5 feet. The build was obviously of the heavy type — with short but stout limbs — expected in a cotylosaur of this size.

It is clear that this skeleton is that of an animal unknown in the roughly contemporaneous deposits of the southwestern Redbeds and, despite the unfortunate lack of knowledge of cranial structure, merits a name for purposes of reference. It may be termed *Limnosceloides dunkardensis*, gen. et sp. nov., a captorhinomorph cotylosaur with combined generic and specific diagnoses based on the character of the femur, in which the antero-proximal trochanteric crest is not extended anteriorly and the distal part of the ventral ridge system is a distinct, if low, crest running diagonally distally to the outer ventral margin of the posterior condyle. The genus may be (very tentatively) assigned to the Limnoscelidae.

***Melanothyris morani*, gen. et sp. nov.**

One of the earliest discoveries of the Pittsburgh parties in the Dunkard was at locality 9, near Blacksville, West Virginia, where numerous small bones and more or less complete skulls and jaws were found in nodules of impure limestone. The material is worthy of careful preparation, but requires more working time than is at the moment available. Most if not all the remains are those of a small cotylosaur. Pending further preparation and study, this may be formally described as *Melanothyris morani*, gen. et sp. nov.; combined generic and specific characters: a captorhinomorph cotylosaur with but a single row of teeth in upper and lower jaws, comparable as far as known to *Romeria* in many regards, but possessing only four pre-maxillary teeth, of which the first two are enlarged, and with "canines" developed at the anterior end of the maxilla, rather than in the more posterior position seen in most primitive reptiles. Genoholotype, no. 8617, from locality 9. The specific name is in honor of Mr. William E. Moran, who discovered the Blacksville locality and participated in all the expeditions on which the material discussed in this paper was collected.

Among the specimens from locality 6 are some seven showing the remains of small upper and lower jaws (no. 8566), seemingly of reptilian nature and possibly belonging to the Blacksville reptile, as suggested by size, contours and nature of the dentitions.

Edaphosaurus raymondi

The grotesque pelycosaur *Edaphosaurus* [*Naosaurus*], ornamented with long neural spines bearing cross-bars, is the one common reptile in the collections. This is not unexpected, for the genus has long been known from late Carboniferous and early Permian deposits in a variety of American and European areas and was apparently ubiquitous in those continents in late Paleozoic times. In this area its remains range vertically from the Conemaugh to the high levels of the Dunkard. Generic identification is, of course, rendered easy through the characteristic development of the spines, of which even a small segment is readily recognizable.

In Texas, *Edaphosaurus* is not in general a conspicuous member of the fauna; its remains are common only in two bonebeds of unusual type which appear to represent swamps; it appears to have been, in all probability, a feeder on the lush vegetation of such areas,¹ and hence is relatively rare in deposits presumably yielding faunas of relatively dry terrestrial areas. The relative abundance of *Edaphosaurus* in the present collections suggests that this was a region which was persistently of a wetter, more swampy type than was the Texas "delta."

Edaphosaurus raymondi was described by Case (1908: 237-238, fig. 7; pl. 59, fig. 3) on the basis of a short segment of spine (no. 1941) from locality C in the Conemaugh group. The spine exhibits the lateral tuberculations characteristic of "*Naosaurus*" (= *Edaphosaurus*) and was tentatively assigned by Case to that genus. This appears eminently reasonable; such tuberculations are unknown in any other form. The spine is much too small for any of the better known American species, and the horizon is a much earlier one. But, *Edaphosaurus mirabilis* (Fritsch) of Bohemia is likewise small and likewise early in appearance (cf. Romer and Price 1940: 388).

Edaphosaurus* cf. *boanerges

In the Washington group and the lowest part of the Greene there have been found at a number of localities fragmentary remains of an *Edaphosaurus* of moderate size, comparable, as far as can be deter-

¹ cf. Romer and Price 1940: 175-176, 387, 390.

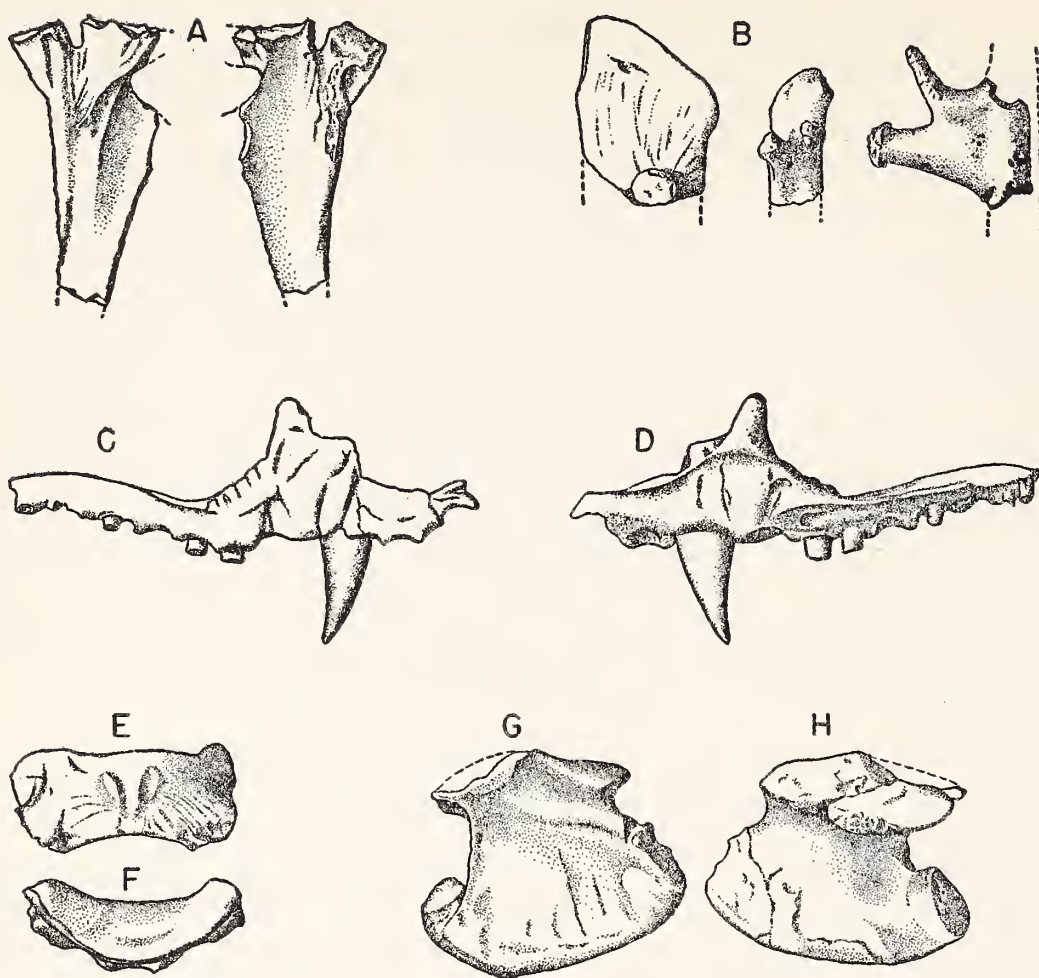


FIG. 13. Pelycosaur remains. *A*, (?) axis rib of *Edaphosaurus*?, no. 8579; *B*, spine fragments of *Edaphosaurus* cf. *cruciger*, no. 8540; *C*, *D*, external and internal views of right maxilla of *Baldwinosaurus*? *dunkardensis*, no. 8563; *E*, *F*, ventral and anterior views of an intercentrum, presumably the atlantal, of a large ophiacodont, no. 8577; *G*, *H*, external and internal views of a sacral rib of ophiacodont type, no. 8576. *A-F*, $\times 1/2$; *G, H*, $\times 1$.

mined, to *E. boanerges* of the Admiral formation (Wichita group) of Texas. These include, in the present collections, spine fragments from localities 8 and 12; an ilium, partial humerus, metapodial and spine fragment from locality 6; also from that locality a puzzling specimen (fig. 13A, no. 8579) which has much the appearance of a crushed pelycosaur stapes but is very probably an axis rib of *Edaphosaurus*; Tilton (1930: 111) reported a spine fragment from locality G; further spine fragments occur at locality H (Stauffer 1916: 88; Stauffer and Schroyer 1920: 147, figs. 45, 46; Whipple and Case 1930: 370); and fragments of spines and ribs are reported from locality I (Whipple and Case 1930: 370-372)¹.

¹ This material was compared by Case to *E. cruciger* of Texas, a species which at that time included the material of the related *E. boanerges*.

Edaphosaurus* cf. *cruciger

E. cruciger of Texas is closely related to *E. boanerges*, but appears to be a descendant characteristic of a higher level in the Wichita group; it is of somewhat larger size and has a greater development of lateral projections and an expansion of the tips of the cervical spines not found in *E. boanerges*. The several citations of *Edaphosaurus* from the upper portion of the Greene group are tentatively assigned to this species since they appear to be from a larger form than that of the Washington group and since the last of the finds noted below shows characters definitely suggestive of *E. cruciger*. These finds include spine fragments from locality 25, spine and rib fragments from locality 28, spine and rib fragments and a clavicle from locality 37, and from locality 35, scraps of vertebrae, spines and ribs and a partial tooth plate. The fragments from the last locality include the tips of two cervical spines (fig. 13B). These show distally a modest expansion comparable to that of *E. cruciger*; as far as is known, no such expansion was present in material (of *E. boanerges*) from the earlier Wichita. There is in this specimen a tendency, apparently, to an exuberant development of lateral growths; a fragment of spine shaft shows a double process at one point, and the smaller tip exhibits a cluster of processes springing from a common base.

***Baldwinonius* ? *dunkardensis* sp. nov.**

A pelycosaurian jaw fragment of uncommon type, from locality 6, is that shown in figure 13 C, D. This consists of the greater part of a right maxillary, from which most of the thin portion lying on the side of the face has been lost but leaving most of the tooth-bearing margin and the thickened area containing the "canine" sockets. Anteriorly, the bone is apparently complete to the premaxillary articulation. Behind this point is a short region which is toothless and with a slight downward "step." There follows an alveolus for a tooth of modest size; behind this a pair of enlarged "canines," one of which is present, the other represented by a large socket. Behind this point there is a sharp reduction in tooth size. The ramus is incomplete posteriorly; the portion preserved contains seven teeth, broken at their bases, or alveoli. The only well-preserved tooth is the "canine." This is pointed and slightly recurved. It is essentially rectangular in section basally and although becoming sharper distally, does not (in contrast to spenacodonts) develop sharp anterior or posterior margins. As far as can be seen, the post-canines are subquadrate at their bases.

Markings on the outer surface appear to be post-mortem checks or cracks. The posterior portion exhibits on the internal aspect a medially-facing surface for apposition to the palatine, above which an upward-facing shelf overlies the tooth sockets. More anteriorly there is a swelling containing the "canine" sockets, which has a thickness of about half its greatest height. A groove, presumably for bloodvessels, crosses the upper margin of this swelling, somewhat as in sphenacodonts. Above this point the swelling rapidly subsides; there is, however, a continuation upward of a finger-shaped thickening of the maxillary bone in somewhat the fashion of the ophiacodonts—a feature responsible for the preservation of this region of the maxilla.

This bone is that of a pelycosaur not readily comparable with any common redbeds type. The enlarged canines, combined with other features which are ophiacodontoid in character, suggest a reference to the (possibly artificial) assemblage of tusked ophiacodontoids which I have termed the Eothyrididae. Most closely comparable is the incompletely known *Baldwinonus trux* of New Mexico (Romer and Price 1940: 255-257). The present specimen differs, however, in that there is but a single pre-"canine" maxillary tooth, and in that the supra-"canine" swelling is less developed dorsally. These characters may be considered as defining a new species referred, with some doubt, to *Baldwinonus*, with no. 8563 as the holotype.

Undetermined Pelycosaur Remains

A few fragmentary specimens from the Dunkard appear to be remains of pelycosaurs of types unknown in the Permian of other regions, but not in themselves worthy of taxonomic description.

(1) From locality 6, a right sacral rib of an ophiacodontoid (no. 8576, fig. 13 G, H). The broad blade of the rib measures 24 mm. in anteroposterior length, and is thus about one-third the dimensions of that of *Ophiacodon retroversus*. Its short, expanded shape and the pronounced swelling at its posterior border indicate its pertinence to an *Ophiacodon*-like animal (cf. Romer and Price 1940: fig. 45A, B). It is seemingly too small to belong to the form described above as *Baldwinonus dunkardensis*.

(2) A large intercentrum, also from locality 6 (no. 8577, fig. 13 E, F). This measures 39 mm. from tip to tip and 16 mm. anteroposteriorly along the midline. It is obviously reptilian, rather than amphibian, and belongs to a reptile of very large size, in which the diameter of the corresponding centrum was on the order of 50 mm. This is a size

reached or approached by few known American Permian reptiles: the pelycosaurs *Ophiacodon major*, *Dimetrodon grandis*, *Cotylorhynchus romeri* and (somewhat smaller and earlier) *Stereophallodon ciscoensis*. The general proportions and the deeply-cupped and smoothly-rounded anterior face strongly suggest that this intercentrum was in the atlantal position, forming part of the articulation with the occipital condyle, and the facets for the articulation of the rib head also suggest this position. If atlantal, this intercentrum differs markedly from that of *Dimetrodon*. This element is not described in *Cotylorhynchus* and is unknown in *Stereophallodon*. The specimen differs in detail from the atlantal intercentrum of *Ophiacodon*, particularly in the presence of paired tuberosities on the ventral surface, but resembles it in general proportions. Not improbably it pertains to a large ophiacodontoid of some type, but one larger than *Baldwinonius? dunkardensis*.

(3) At locality 33 was found a fragment of a bone V-shaped in section which resembles the base of the sphenoidal rostrum of a pelycosaur (no. 8574). The form possessing it must have been of considerable size but the fragment is too imperfect to permit of satisfactory identification.

Indeterminate Reptilian (?) Remains

As noted in Moran's accompanying paper (under locality D), Condit (1912: 28, 39, 283) reported reptilian bones from the Ewing limestone and Birmingham shale of the Conemaugh of Ohio; these bones, however, were not preserved (Case 1915: 84) and are hence indeterminate.

Footprints

Footprints of tetrapods have been discovered in a number of localities in the late Pennsylvanian and in the Dunkard of this region. They are currently being studied by Mr. Donald Baird, and I shall here merely review briefly those published.

Tilton in 1926 (386-391, pl. 11, figs. A-E) described a number of footprints from West Union, Doddridge Co., West Virginia, in the Waynesburg sandstone of the Washington formation; these he named *Baropus waynesburgensis* (1931: 551-555, figs. 3, 4). They are broad, stub-toed tracks which, as Gilmore pointed out, are similar to those described from the late Carboniferous and early Permian of other regions as *Allopus* (cf. Gilmore 1926: 30), and appear to pertain to rhachitomous amphibians. The West Virginia animal was one of good size; length and breadth of a forefoot track is 115 mm., thus not inappropriate for an animal of about the size of a typical *Eryops* of

the Wichita of Texas (cf. the forefoot of *Eryops* as described by Gregory, Miner, and Noble 1923).

Carman (1927: 386-388, pl. 2) described a slab of footprints from a horizon just below the Benwood limestone member of the Monongahela formation from Center Township, Morgan Co., Ohio.¹ These constitute a trackway with a breadth of about 250 mm. and a stride of 540 mm.

Tilton further described from the sandstone of the lower Dunkard from Berea, Ritchie Co., West Virginia, a pair of tracks of distinctly reptilian type (1931: 547-551, figs. 1, 2). He notes that they are of a sort which might have been made by *Dimetrodon* or a related pelycosaur. This is possible, but an even closer comparison can be made with *Edaphosaurus*. Tilton gave the name *Dimetrodon berea* to these prints; they were renamed *Dimetropus* by Romer and Price (1940: 336).

Happ and Alexander (1934) described several types of small footprints from the Dunkard — presumably the horizon of the Marietta sandstone — at Sherman, West Virginia.

Coprolites

In various early Permian deposits, and to a lesser degree in those of late Pennsylvanian age, are found numerous animal faeces in the form of coprolites. These are particularly abundant in the Texas Redbeds. Striking and abundant are slender, elongate, cigar-shaped specimens which show a spiral surface marking at one end. These were obviously excreted by forms with a spiral valve type of intestinal structure. Such an intestine is known to have been present in the "pleuracanth" sharks which were ubiquitous inhabitants of late Paleozoic fresh waters, and it is probable that the greater part, at least, of such coprolites are of "pleuracanth" origin. However, a spiral valve is present in lungfishes, and there is some possibility that Paleozoic crossopterygians and perhaps even some of the more primitive actinopterygians and the more primitive amphibians may have retained such a structure. In consequence we cannot be sure that all coprolites of spiral type are of "pleuracanth" origin.

Abundant coprolites of this type have been described by Price (1927: 214-225, pls. 11-18; Price, Tucker and Haught 1938: 157) from the Round Knob formation (Pittsburgh shale) of the Conemaugh from the

¹ Carman further described other amphibian footprints from an earlier horizon (Allegheny formation) not considered here.

Morgantown region of West Virginia, and Stauffer and Schroyer (1920: 146, 147, figs. 30-35, 41-44) have described other specimens from the Elm Grove limestone and Creston Redbeds of the Washington formation at Raven Rocks and Elba, Ohio, respectively.

Less commonly collected in the Texas Redbeds are coprolites lacking the spiral structure and taking the general form of oval, flattened, and rather amorphous masses. Presumably such coprolites were generally of amphibian and reptilian derivation. Their rareness in collections is due in part to their scarcity in the deposits, but also due to the fact that the collector is less liable to recognize them as of "organic derivation." Tilton (1926: 388, 394) has reported such coprolites from the Ninevah and Lower Rockport limestones of the Greene group of the Dunkard.

In the present material, coprolites were collected at localities 18, 20 and 26, and were found but not collected at a number of other localities.

DISCUSSION

The present collection is, as noted earlier, of interest in two regards: (1) the Dunkard material, constituting its bulk, gives us an opportunity to study the early Permian vertebrate fauna of a region both topographically and, it seems, environmentally as well, far removed from the classic Redbeds of the American Southwest; (2) the late Pennsylvanian materials give us a glimpse of vertebrate faunas transitional between those of the typical Coal Measures and those of the Permian.

Occurrences of vertebrates in the late Paleozoic of the region here discussed are listed by localities, stratigraphically arranged, in the accompanying table. Most of these localities (from number 4 on) lie in the Dunkard, and represent a broad spread of horizons covering nearly the whole extent of the Washington and Greene groups which constitute that series.

The exact correlation of the Dunkard with the Texas beds is open to some question. Although the Washington flora has a Pennsylvanian aspect, the base of the Dunkard is generally considered to be the base of the Permian in this region, and the base of the Wichita Group of Texas is held to be at this same horizon. Hence, part and perhaps all of the Dunkard can be correlated with the fossiliferous Texas beds. In the latter state, the vertebrate faunas continue upward, with gradual change, into the Clear Fork group. Does any part of the

Dunkard extend this far up the column? No positive answer can be given, but there is some suggestive evidence in the negative. *Edaphosaurus* is represented in both areas. In Texas, *E. boanerges* appears to be the lower to middle Wichita species, *E. cruciger* that of the upper Wichita and *E. pogonias* the Clear Fork form. The three apparently form a species phylum, the later forms being successively larger and with increasing "exuberance" of spine development. As noted earlier, the Dunkard *Edaphosaurus* material from the Washington and lower Greene appears comparable to *E. boanerges*, that from upper levels of the Greene to *E. cruciger*; none exhibits characteristics of *E. pogonias*. We may reasonably conclude that the Dunkard, as a whole, is essentially comparable to the Wichita group of Texas and compare the faunas on that basis.

Both Dunkard and Wichita collections contain fairly abundant freshwater fish remains, and the content is very similar in the two. Both yield plentiful *Dittodus* teeth and (more rarely) spine and cartilage material of this "pleuracanth" shark type; both have abundant remains of the lungfish *Sagenodus*; both have remains (usually not well-preserved) of palaeoniscoids; a crossopterygian — presumably *Ectosteorhachis* in both cases — is present but not common. It is possible that differences of at least specific nature may eventually be discovered, but at present this is not the case.

In the amphibian fauna, the common large labyrinthodont in both areas is the familiar *Eryops*. The common Texas Wichita labyrinthodont of smaller size is *Trimerorhachis*. This cannot be identified with certainty in the Dunkard, but we have noted the presence, in a number of localities, of fragmentary remains of rhachitomes of roughly comparable size and of seemingly similar character. *Lysorophus*, present in the Dunkard, is not recorded in the Wichita; but since the genus had developed before the end of the Carboniferous and is present in Texas in the later Clear Fork beds, it may yet be found in the Wichita. "Horned" nectridians are present in both regions, although the Texas form, *Diplocaulus*, is relatively rare in Wichita horizons.

These resemblances between the Dunkard and Wichita amphibian faunas are balanced by marked differences. Various Wichita forms are absent in the Dunkard material. In the case of certain rare types, seeming absence may be due to chance. There are, however, two common Texas types which, if present in the region, would have been

expected in Dunkard collections; these are the aquatic embolomere *Archeria* [*Cricotus*], whose characteristic centra are readily preserved and easily recognized, and the terrestrial rhachitomes of the dissorophid group. No trace of either has been so far discovered in the Dunkard. As was said above, long-horned nectridians are common in both the Texas and Dunkard beds. But, although I at first assumed that the Dunkard animal was generically identical with *Diplocaulus* of Texas, it appears that we are dealing, in the genus *Diploceraspis*, with a long-horned form which evolved locally in parallel fashion. A striking novelty in the Dunkard is the relatively enormous snake-like water-dweller *Megamolgophis*, a form quite unknown in the western Redbeds.

A still more marked contrast between the Dunkard and the Wichita lies in the nature of the known reptilian fauna. In Texas, perhaps 50 per cent of all material collected is reptilian — principally remains of cotylosaurs and pelycosaurs. In the Texas fauna, *Edaphosaurus* is a rare animal, apart from two bog deposits which have fortunately yielded a quantity of specimens. In the Dunkard, *Edaphosaurus* is the one relatively common reptile, with identifiable remains reported from some ten localities. Apart from *Edaphosaurus*, reptiles of any sort are rare indeed. They include only the little Blacksville cotylosaur *Melanothyris*, the half skeleton of *Limnosceloides*, the jaw fragment doubtfully assigned to *Baldwinonius* and a very few further scraps — none directly comparable with Texas forms. Captorhinomorph cotylosaurs are rare, diadectids unknown; ophiacodont pelycosaurs are represented only by fragments, edaphosauroids other than *Edaphosaurus* are absent. Most notably, there is no positive indication of the presence of *Dimetrodon* or any member of this sphenacodont group of carnivorous pelycosaurs, which form one of the commonest elements in the Texas fauna (and that of New Mexico as well).

To what are these differences due? In part they may be accounted for by the reasonable assumption that we are dealing with two distinct land areas; connections between them may have been indirect and tenuous or may have been completely interrupted for some modest period of geologic time. On such grounds we perhaps may account for the absence of the embolomeres in the Dunkard, the presence of different types of diplocaulids and the finding in the Dunkard of a few forms, such as *Melanothyris*, *Limnosceloides* and, especially, *Megamolgophis*, which are quite unknown in the abundant Texas material.

It is, however, probable that a great part of the faunal differences

between the two areas may be attributed to differences in the environments in which the two faunas lived. Of the prominent Texas groups, absent or poorly represented in the Dunkard, *Archeria* was essentially aquatic, ophiacodonts in part amphibious, but the other absentees were terrestrial in nature, or mainly so. The missing dissorophids appear to have been the most terrestrial of amphibians. *Eryops*, present in the Dunkard as well as Texas, was a partially terrestrial amphibian type with rather well-developed limbs; but of all Dunkard amphibian citations, 60 per cent are of purely aquatic types — *Diploceraspis* and the lysorophid group—which were quite incapable of venturing onto the land. The most notable Dunkard amphibian type not known from Texas is of this sort — the giant lysorophid *Megamolgophis*. Reptiles, we have noted, are for the most part extremely rare in the Dunkard; and the early reptiles were in general terrestrial types. I have elsewhere (Romer and Price 1940: 175-176) commented on the habits of *Edaphosaurus*, the one reptile well represented in the Dunkard. It appears to have been a plant-eater which fed on lush swamp plants and hence is much more likely to be found in swamp or bog deposits than in beds which, although fluviatile in origin, lay adjacent to areas of dry land.

The conclusion to which the discussion above leads us is an obvious one — that the conditions of deposition in the Dunkard area were much more favorable to the preservation of aquatic (in contrast to terrestrial) tetrapods than was the case in Texas; from which may not unreasonably be drawn the further conclusion that the Dunkard area was one of which the living inhabitants were predominantly aquatic or amphibious in nature.

These conclusions from the fossil vertebrate material appear to be in agreement with other evidence. The Wichita beds of Texas are of fluviatile and presumably deltaic origin and contain numerous aquatic animals. But plants — mainly xerophytic — and sediments alike suggest that, on the whole, the region was not swampy in nature, but included much dry land — and rather dry, dry land, at that. One can envisage a situation perhaps comparable to the deltas of such rivers as the Tigris-Euphrates system or the Indus, where conditions favorable to aquatic and amphibious forms are present in the immediate neighborhood of the stream channels, but where dry land areas suitable for purely terrestrial forms are close at hand.

Quite different, apparently, is the Dunkard situation. Earlier, the

region had been one with a cyclic repetition of coal swamps and flooding by marine waters. Above the Conemaugh, marine limestones disappear, to be replaced by limestones of freshwater origin, but conditions appear to have been little changed. Cyclic recurrences of coal beds continue throughout most of the Dunkard series and there is little development of redbeds. The plants, of the Washington group, at least, show little change from the presumably lush flora of the late Pennsylvanian. The general impression of the Dunkard area gained from nonvertebrate evidence is thus that of a flat, well-watered coastal region with abundant swamps and lagoons; a region ecologically ideal for an abundant fauna of freshwater fishes and aquatic or swamp-dwelling tetrapods, but with relatively few dry land areas in which the more purely terrestrial types of amphibians and reptiles could flourish in any numbers. The outer part of the Mississippi delta today presents a comparable situation.

This conclusion is in keeping with the nature of the animals noted as making up the Dunkard faunal list: an abundance of fishes, reasonably considered as inhabitants of the streams and lagoons of such an area, including predaceous pleuracanth sharks, lungfishes, palaeoniscoids and — rarer in numbers — crossopterygians and acanthodians; purely aquatic pool-dwelling amphibians such as the “horned” *Diploceraspis* and the lysorophids; a more limited number of rhachitomes of amphibious habits, including *Eryops* and one or more obscure smaller types; of reptiles, an abundance of edaphosaurs which presumably fed on lush swamp vegetation, but few remains of other sorts. The Dunkard facies of the early Permian fauna is thus markedly different from that presented in the southwestern Redbeds. Were we, however, able to get a glimpse of the fauna a bit farther to the east toward the mountains from which the Dunkard sediments came, we might well find a Permian tetrapod assemblage much more comparable with that recorded from Texas or New Mexico.

Pennsylvanian-Permian transition. As has been said, the area here discussed gives us the one opportunity present in North America of obtaining a continuous record of continental vertebrate life from the typical Pennsylvanian coal swamps on into the Permian. The materials collected by the Carnegie Museum parties enable us to make a beginning toward the study of this record. Unfortunately, however, almost nothing was found in the Monongahela group, with which the Pennsylvanian system terminates, and the Conemaugh materials, mainly from the Soho quarry (locality 1), are mostly of fragmentary

nature. We have a tantalizing glimpse of the nature of the transitional faunas; little more. The freshwater fish faunas appear to continue onward from Pennsylvanian to Permian without any appreciable break, although more adequate knowledge would probably indicate changes of specific and quite possibly generic nature among "pleuracanth," lungfishes and crossopterygians and presumably changes of greater magnitude (although no doubt gradual in nature) in the poorly known palaeoniscoid fauna. The known amphibian material is in great measure obscure in nature, but there are two points which stand out: (1) the presence, in *Glaukerpeton*, of an early forerunner of the typically Permian eryopsid group of rhachitomes, and (2) indications (in the form of fragmentary remains) of the rapid development of a long-horned nectridian from an Allegheny predecessor of less spectacular type. Undoubtedly the radiation of primitive reptilian groups was well under way in Conemaugh times, but the known material gives but two isolated facts: that primitive diadectid cotylosaurs, antecedent to those of the Permian, were already in existence (*Desmatodon* and a fragment from Soho); and that (in confirmation of an earlier report from Europe) the specialized pelycosaur *Edaphosaurus* had already evolved.

Although these few data are of interest, it must be admitted that the knowledge of vertebrate evolution gained so far from the Conemaugh is tantalizingly small. But the finds already made give us the hope of future discoveries to broaden the picture of an important transitional stage in tetrapod evolution.

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EXPLANATION OF PLATE I

- FIG. 1. *Sagenodus* cf. *periprion*, pterygoid tooth plate. No. 8501. $\times 1$.
FIG. 2. The same, mandibular tooth plate. No. 8502. $\times 1$.
FIG. 3. *Desmatodon hollandi*, teeth of holotype in crown view, about twice natural size.
FIG. 4. Teeth of small unnamed diadectid from the Conemaugh formation. No. 8567. $\times 2$.
FIG. 5. Parasphenoid of small amphibian. No. 8530. $\times 1$.
FIG. 6. Problematical impression showing *Diploceraspis*-like sculpture. No. 8547. $\times 1$.
FIG. 7. *Lysorophus minutus*, holotype. No. 8564. $\times 1$.
FIG. 8. "Horn" of *Diploceraspis burkei*. No. 8552. $\times 1$.



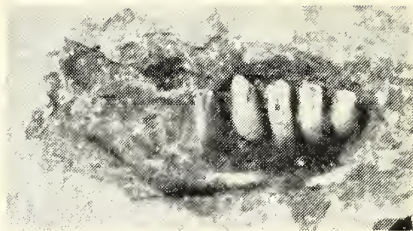
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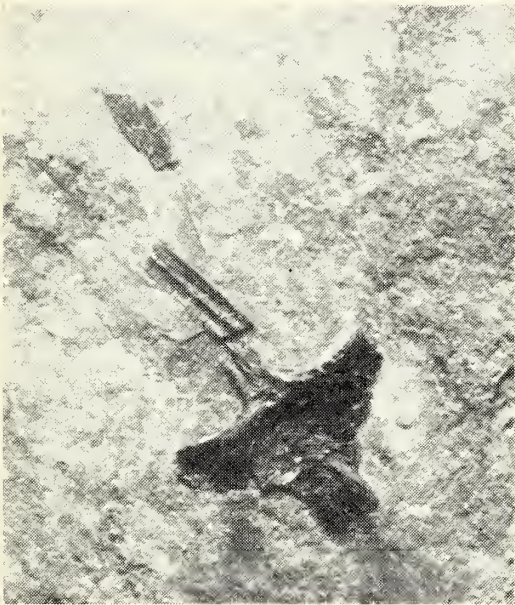
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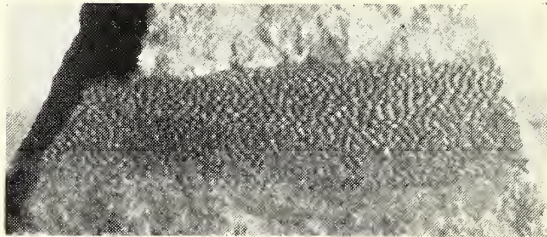
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EXPLANATION OF PLATE 2

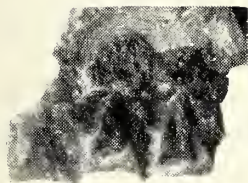
- FIG. 1. *Eryops* cf. *megacephalus*, part of skull roof. No. 8532. $\times 1/2$.
- FIG 2. The same, cleithrum, scapula and clavicle. No. 8535. $\times 1/3$ approx.
- FIGS. 3, 4. Vertebrae of small rhachitome, exhibiting most of intercentra in figure 3, and in figure 4 the other side of the slab showing the opposite ends of these elements, pleurocentra and poorly preserved neural arches. No. 8569. $\times 1/2$.
- FIG. 5. *Diploceraspis burkei*, incomplete holotype skull. No. 8551. $\times 1/2$.
- FIG. 6. *Eryops* cf. *megacephalus*, nearly complete skull in dorsal view. No. 8531. $\times 1/6$ approx.
- FIG. 7. *Glaukerpeton avinoffi*, slab containing type skull in dorsal view. No. 8539. $\times 1/5$ approx.



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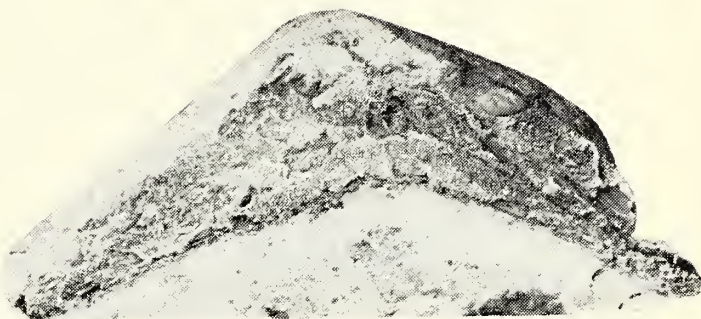
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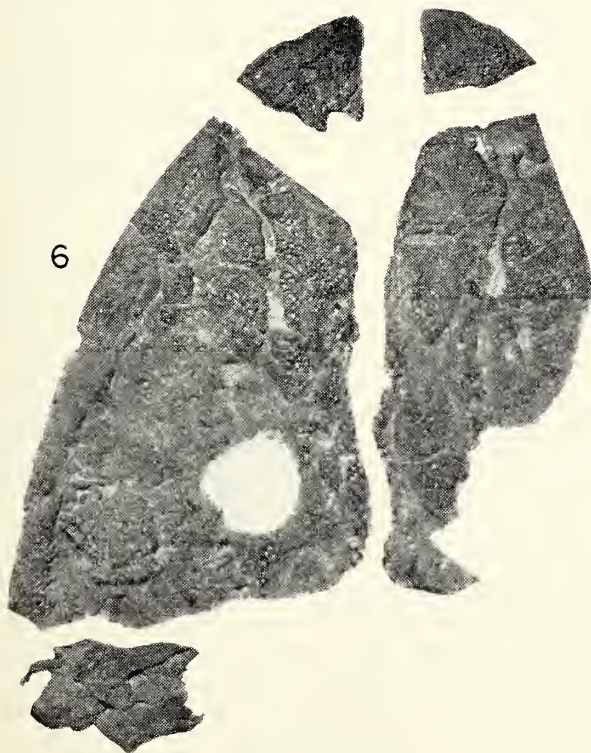
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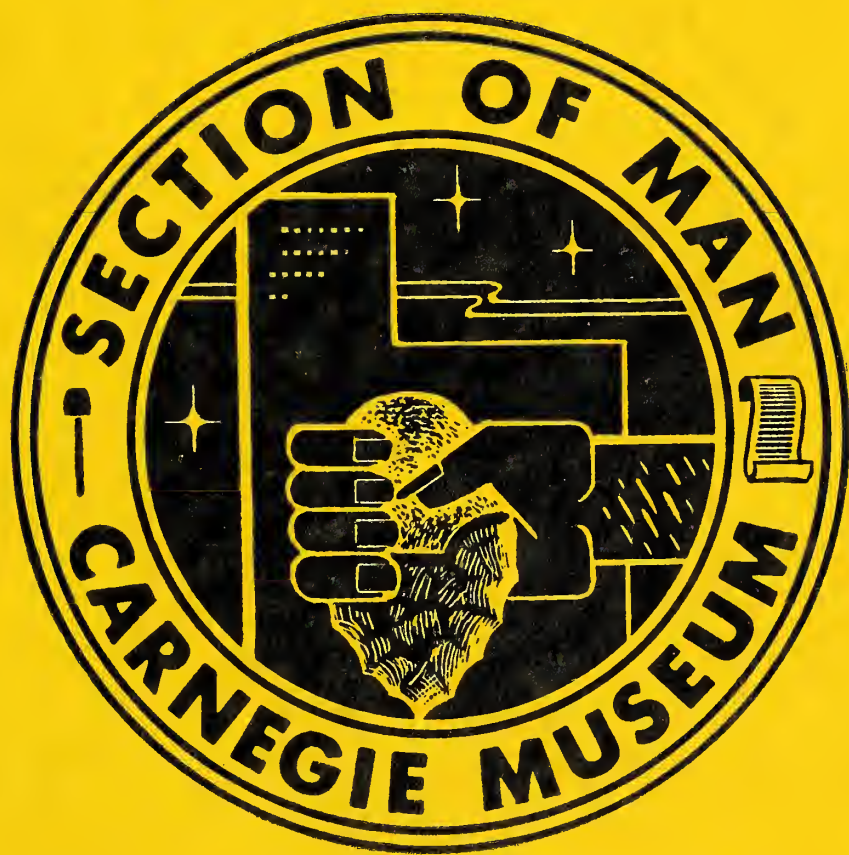


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ANTHROPOLOGICAL SERIES



NUMBER

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ANTHROPOLOGICAL SERIES

No. 1

AN ARCHEOLOGICAL SURVEY OF THE PROPOSED SHENANGO RIVER RESERVOIR AREA IN OHIO AND PENNSYLVANIA

By

WILLIAM J. MAYER-OAKES

Field Archeologist, Carnegie Museum

Pittsburg
ANNALS OF THE CARNEGIE MUSEUM

VOL. 33, ART. 3
(PLATES 3-16, MAPS 1-2)

February 10, 1953

PREFACE

When Carnegie Museum's Upper Ohio Valley Archeological Survey, a three-year project made possible by the financial support of the Sarah Mellon Scaife Foundation of Pittsburgh, was launched, James L. Swauger, Curator of the Section of Man, and William J. Mayer-Oakes, Field Archeologist, were asked to give prompt attention to any sites that might be destroyed in the near future by flood control impoundments or other man-made changes in terrain. Mr. Mayer-Oakes accordingly offered to co-operate with the River Basin Surveys, the National Park Service and the Corps of Engineers in making field studies of proposed reservoir areas, in the Upper Ohio Valley, that were not then being investigated by federal archeologists. Dr. Frank H. H. Roberts, Director, River Basin Surveys, and Dr. John M. Corbett, National Park Service, welcomed this offer of co-operation and agreed that the Carnegie Museum field party should survey the area lying within the proposed Shenango River Reservoir, with Ohio State Museum participating in the study of the Ohio portion. It was understood that staff members of the two institutions would report their findings separately, offer recommendations for excavation of important sites, and indicate which of these might be undertaken by the co-operating museums.

Mr. Mayer-Oakes has completed his assignment in a most commendable fashion. It is entirely appropriate, therefore, that this report should launch Carnegie Museum's new anthropological series.

WALLACE RICHARDS,
Director, Carnegie Museum



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ART. 3. AN ARCHEOLOGICAL SURVEY OF THE PROPOSED SHENANGO RIVER RESERVOIR AREA IN OHIO AND PENNSYLVANIA

INTRODUCTION

Carnegie Museum's Upper Ohio Valley Archeological Survey (UOVAS) conducted field work in the Beaver River drainage area during June and July, 1951. This included the Shenango River and, specifically, the proposed reservoir area indicated on map 1. Field work in the reservoir area required 14 days; this included reconnaissance and the examination and photographing of collections.

Because a portion of the proposed reservoir extends into Ohio, we were assisted there for one day by Robert Goslin of Ohio State Museum. The archeological survey of the Pennsylvania section was carried out by William J. Mayer-Oakes with the aid of two assistants, Arthur M. Hayes and Edward V. McMichael. Invaluable local assistance was provided by Orvis Anderson of Sharpsville, Pennsylvania, president of the Mercer County Historical Society. Walter J. Hitchcock of Sharpsville has collected from various Indian sites in this vicinity for many years. His notes, well-documented collections and active field assistance were of great value. Various other local people helped the survey with information and access to sites and collections.

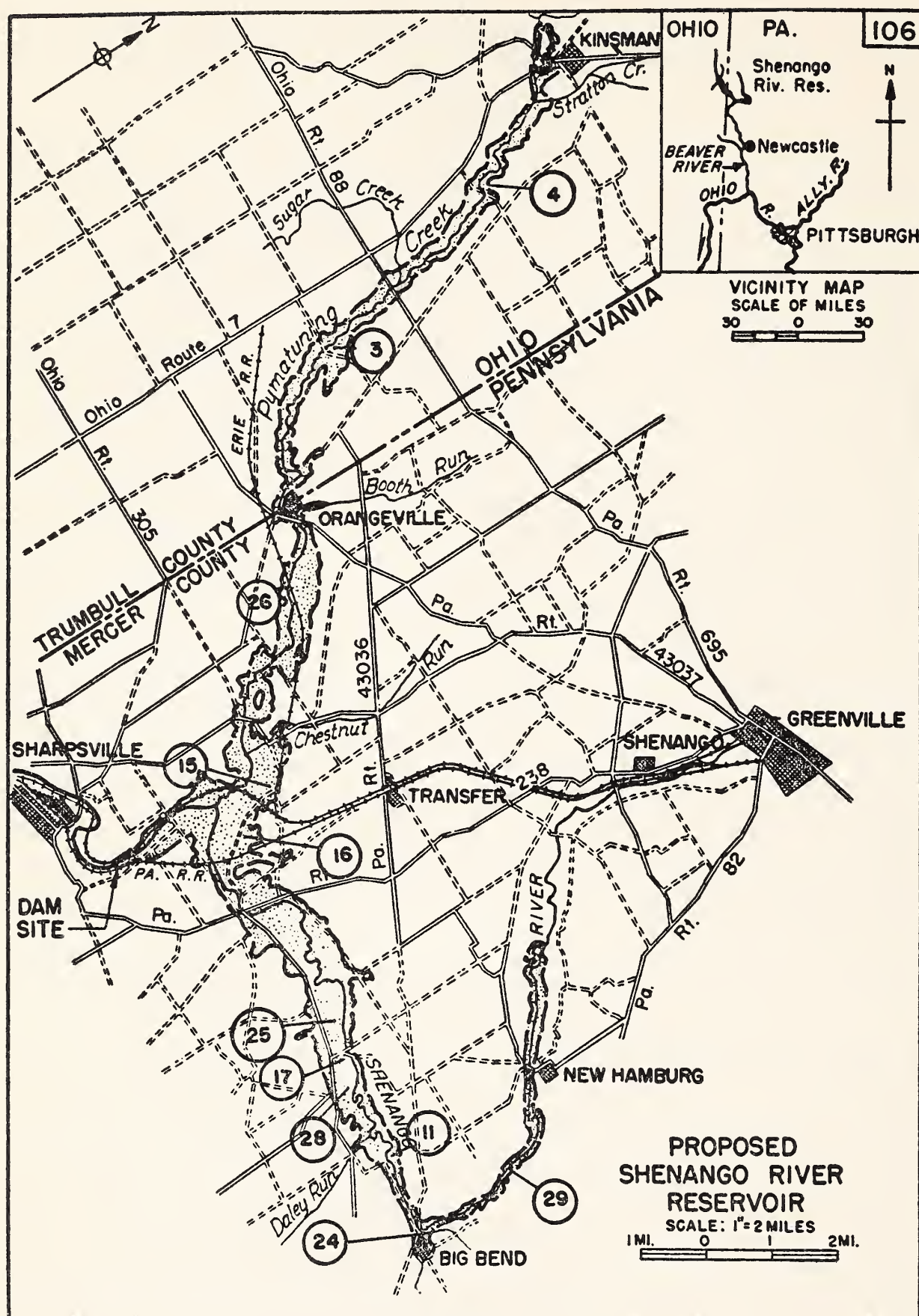
The larger program of UOVAS (Swauger, 1950) is establishing the comparative background used for this report. The extensive field work on the Beaver drainage (Mayer-Oakes, 1952a) provides data essential for the interpretation of this unit of work in the Shenango Reservoir.

The reservoir, with the proposed dam site about one mile above Sharpsville (see map 1), will extend about 16 miles on the Shenango in Mercer County, Pennsylvania and about 17 miles on Pymatuning Creek in Mercer County and in Trumbull County, Ohio. Within the limits of the proposed reservoir, full at 912 feet above mean sea level, 11 Indian occupation sites have been recorded.

DESCRIPTIONS AND INTERPRETATIONS OF INDIVIDUAL SITES

Site No. 3 on Map 1

33Tr3 is a small campsite on the first floodplain at the junction of a small run with Pymatuning Creek. The site is on the east bank of Pymatuning Creek about one and one-fourth miles SSE of the village of Vernon, Ohio. The entire site would be covered by the 912-foot full reservoir. The owner, E. L. Hall, R.D. Burghill, Ohio, stated that artifacts have been found here in the past but that he has no collection. Goslin and Mayer-Oakes picked up four chert flakes and one projectile point (a Whittlesey focus type according to Goslin) in a brief surface hunt. The site was evidently a minor one. Artifact finds were reported from the area immediately south of here, but no surface indications of this could be obtained owing to growth of vegetation.



MAP 1

The base copies of this map were provided by the Corps of Engineers, Pittsburgh District, through the kindness of H. E. Anderson

Site No. 4 on Map 1

33Tr4 is an extensive campsite and village area, spilling over from the second terrace on the east bank of Pymatuning Creek into the area to be flooded, about two and one-half miles SSE of the town of Kinsman, Ohio. Only the lower portion of this site would be covered by the full reservoir. The owner, Harry Allen, R.D. 2, Kinsman, Ohio, reported that many artifacts had been found here. He allowed us to examine and to photograph a small collection he had gathered from the site during the past 50 years. Selected items from this collection are illustrated in figures 1 and 2.

The content of this collection indicates that the site was probably used by several groups of prehistoric people. The Archaic period is represented by beveled adzes, a full-grooved axe, four types of spearthrower weights (banner-stones), and the stemmed and side-notched projectile point types. An Early to Middle Woodland period is indicated by the gorget types, the thick double-corded pottery ware, and the tube fragments of both pottery and Ohio fireclay. Interestingly enough, three of the eight gorgets are made of cannel coal, the first known instance for this area. An occupation during Late Prehistoric times is indicated by the occurrence of triangular points and a thin, incised grit-tempered pottery ware. Because of vegetation, surface hunting on this site was impossible but the presence of chert flakes and charcoal in the soil, plus the owner's collection, indicate an intensive occupation.

Site No. 11 on Map 1

36Me11 is a small village site on the first terrace north of the Shenango about one mile above the Fruit's Mill Bridge. The entire site would be covered by the full reservoir. The owner, Floyd Slater, has a small collection of stemmed and notched points recovered from the hills north of this site which are apparently unrelated to it. William A. Hunter, senior archivist of the Pennsylvania Museum and Historical Commission has definitely established this site as the historic "Pymatuning Town," a Delaware village of 1760-1777. In a personal communication to the writer he states:

C. A. Hanna's suggestion in *The Wilderness Trail*, that the town stood "at or near the mouth of Pymatuning Creek," overlooks the fact that until after the time of white settlement, Pymatuning meant the upper reaches of present Shenango River, rather than the present Pymatuning Creek. Thus, the swamp, now a reservoir, at the head of present Shenango River retained the name Pymatuning. Unfortunately, later writers, such as Donehoo and Sipe, have been content to repeat Hanna's guess.

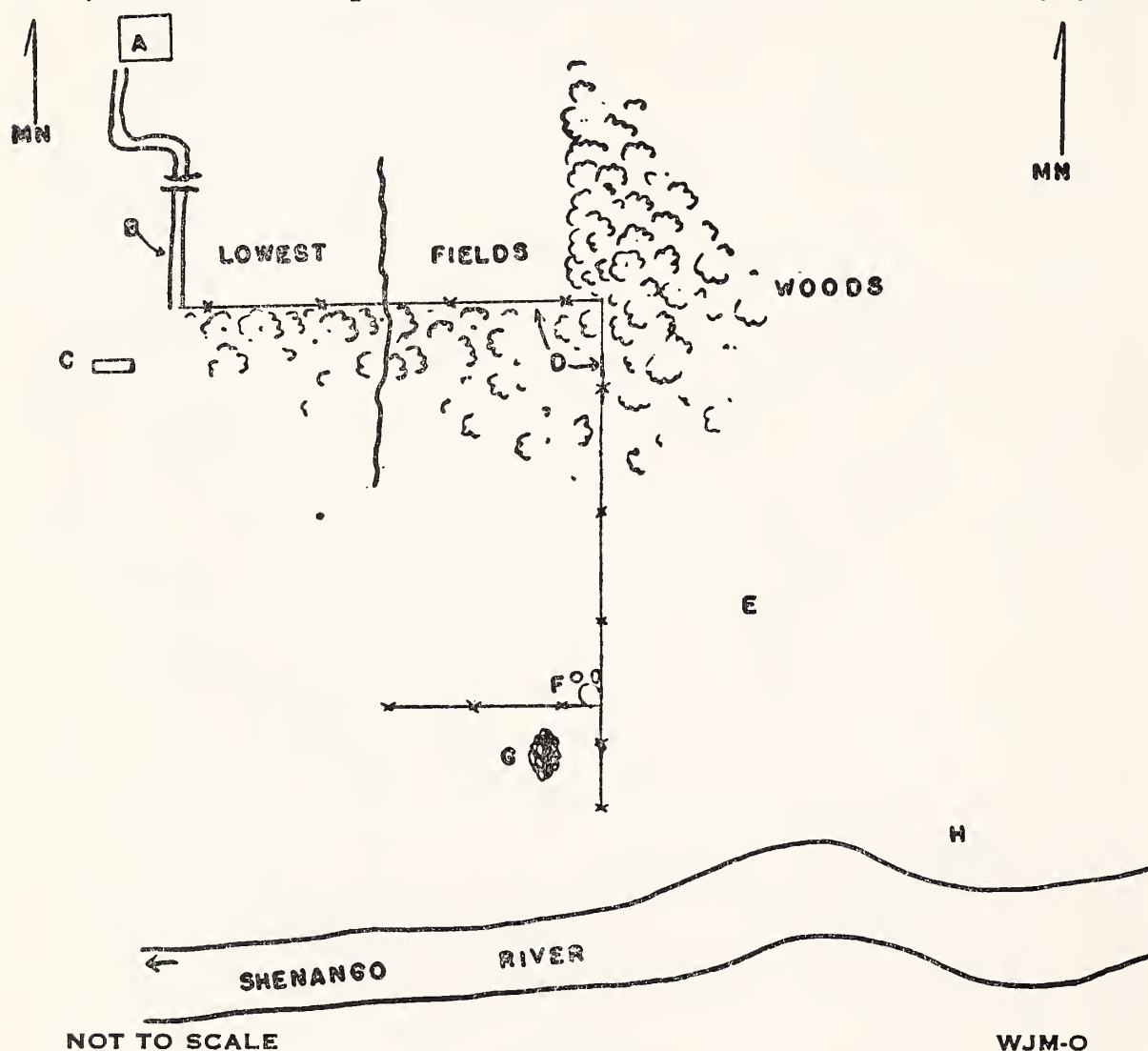
Both Thomas Hutchins, who seems to make the earliest mention of the Indian town, about 1761, and Andrew Henderson, who surveyed the area in 1785, and whose notes make precise identification of the site possible, place Pymatuning town on the north (right) bank of the present Shenango River, west of the Big Bend but east of the town of Clarksville.

In the notes accompanying an unpublished sketch map, undated but very probably made in the fall of 1761, Hutchins says: "15 Houses at Peymatuning last fall and Consisted of 40 Warriors . . . in the month of April most of the Indians at Peymetuning talked of moving some to Tuscarawas and some to Muskingum."

In spite of this talk of moving, it is clear from casual references that the town remained occupied for another fifteen years or so.

Henderson's notes are to be found in print in the *Historical Register: Notes and Queries*, Vol. I, No. 2 (April, 1883), pages 148-153. He reports that in 1785 some of the Indian cabins were still standing; but he thought the cornfields had not been cultivated for some eight or ten years. This would place the date of abandonment at 1777, at latest. I should suggest the possibility that General Edward Hand's notorious "Squaw Campaign" might have been the cause; for Moravian mission diaries of this period report that in consequence of his campaign the outlying Delaware towns in this area were abandoned, the Indians moving to the Muskingum and other less-exposed places.

A minor excavation here in 1934 by Donald A. Cadzow of the Pennsylvania Museum and Historical Commission recovered potsherds and other artifacts, which he ascribed to a minor Algonkin occupation (Cadzow, 1935). At that time, the fact that this was also the location of the historic town was not known. The area was formerly farmed but has been abandoned for some years. As a consequence, surface indications of the site were negligible.



SKETCH MAP, 36Mell — A. Slater house B. Field road C. Water trough
D. Line fence E. 1934 excavations (150 ft. NE of F) F. Documented corner
(3 trees) G. Stone pile H. Alleged burial ground vicinity (ca. 400 yds. SE of F)

The 1934 excavations, however, are easily discernible and with the aid of the sketch map (map 2) it is possible to relocate this site.

Site No. 15 on Map 1

36Me15, the site of an historic Indian grave approximately two miles NW of the town of Clarksville, Pennsylvania, would be covered by the full reservoir. The owner, Frank Stewart, Sharpsville, excavated here in 1949 for gravel and uncovered the grave of one individual of the French and Indian War period (Witthoft, n.d.). The skeleton and some of the associated artifacts are now being studied by Witthoft in Harrisburg, while the remainder of the artifacts are on display at Sharpsville High School. Some of the artifacts found with the skeleton are shown in figures 3 and 4.

Site No. 16 on Map 1

36Me16 (Hitchcock, no. 21) is an extensive occupation site on the rolling ground about 2000 feet SE of 36Me15. This entire site would be covered by the full reservoir. The owner, Ellis J. Stewart, Transfer, Pennsylvania, has an excellent collection gathered from the surface of this site during the past 50-75 years by himself and his father. This collection, the largest known from the Shenango Reservoir area, comprises the following items, many of which are illustrated in figures 5-14:

GROUND STONE	CHIPPED STONE
2 cylindrical pestles	3 lanceolate points
5 full-grooved axes	297 side-notched points
18 adzes	155 stemmed points
1 beveled adze	86 corner-notched points
9 celts	68 bifurcated-base points
8 bannerstones	18 triangular points
4 gorgets	26 bunts
4 Ohio fireclay tubes	6 plano-convex end scrapers
(2 of blocked-end type)	33 drills
2 grooved pebbles	1 Flint Ridge flake knife
many bi-pitted stones	89 (of 150 originally found)
many hammerstones	Flint Ridge cache blades

About 15 years ago Mr. Stewart unearthed part of a cache of leaf-shaped Flint Ridge blades while plowing the site. They were buried in the blue clay subsoil, evidently in a shallow pit. The following year's plowing turned over the rest of the cache which had originally been composed of about 150 blades. The range in size and shape of the blades still remaining in the Stewart collection is shown in figure 5.

Surface hunting on this site produced many chert flakes as evidence of occupation. The majority were Onondaga and a local dark chert, but a fair amount of Flint Ridge material was gathered. In addition, 3 side-notched points, 3 scrapers, 1 drill base, 1 knife, 1 triangular point and 1 large Flint Ridge core were recovered. Pottery was present but very scarce — four grit-tempered smoothed sherds were found in an area which may represent a midden or concentration of pits.

This site was evidently heavily occupied during two main periods. The Archaic occupation is denoted by the beveled and plain adzes, full-grooved

axes, three types of spearthrower weights (bannerstones), the stemmed and side-notched projectile points and probably by the snub-nose plano-convex end scrapers. An Early to Middle Woodland period with emphasis on Hopewellian characteristics is indicated by the open- and blocked-end tube fragments, gorgets, Flint Ridge flake knives and cache blades, and smoothed grit-tempered pottery. No mounds or graves have been reported from the site, but Mayer-Oakes (1952b, p. 2) has recorded a Hopewell mound in Trumbull County, Ohio, less than 30 miles to the west and a Hopewell burial some 25 miles south on the Shenango in Lawrence County, Pennsylvania. The triangular projectile points afford slight evidence for a later occupation.

Site No. 17 on Map 1

36Me17 (Hitchcock CLR or no. 18) is a fairly limited but intensive occupation site on the second terrace south of the Shenango about 1000 feet south of the Fruit's Mill Bridge, which would be inundated by the full reservoir. Joe Borkovich, R.D. 2, Sharpsville, the owner of the property, has no collection, but R. K. Cartwright and W. J. Hitchcock of Sharpsville, both have materials from the site, some of which are shown in figures 16-20.

Surface hunting produced 54 shell-tempered and 11 grit-tempered potsherds, one triangular point and many chert flakes. From the variety of materials which have been found here in the past it appears that several occupations are represented. The adzes, lanceolate and stemmed points, and three types of spearthrower weights (bannerstones) no doubt represent the Archaic peoples. Some indication of an Early to Middle Woodland occupation is seen in the Ohio fireclay tubes, gorgets, notched points, flake knife, and possibly the grit-tempered pottery. The major occupation, however, seems to have been during the Late Prehistoric period judging by the presence of small triangular points and shell-tempered pottery, sometimes with incised-line decoration.

Site No. 24 on Map 1

36Me24 (Hitchcock, no. 7) is a limited but intensive occupation area on the second bench east of the Shenango at the point known as "Big Bend." The site extends from the river edge back 200 yards and is bounded on the south by Lackawannock Creek and on the north by an unnamed run. When full, the reservoir would cover this site completely. The owner, Mont Davis of Big Bend, has no collection, but W. J. Hitchcock and R. K. Cartwright have both collected here and a selection of their artifacts may be seen in figures 21 and 22. Hitchcock (n.d.) describes the site as follows:

This site is located in Jefferson township, Mercer County, on the southeast bank of the Shenango River, at the "Big Bend" of the stream. The road which crosses the bridge at this point has been built directly through the site, thus dividing it into two parts. Both of these divisions are closely contiguous to the river, and corners of them approach almost to the bridge. The finds here were in considerable variety and included arrow and spear heads, celts, hammerstones, smoothers, mullers, scrapers, and flint knives. Many others found were of undetermined use. Flint refuse and flakes were abundant. Superimposed was a great quantity of slag, indicating, as local historic annals relate, the later location of an iron furnace

here. Very few potsherds were recovered. The hillsides across a small stream, northeast of the actual site, on search, yielded numerous flint and a few other stone pieces, while the surface of the land across the bridge north and west of the river was almost barren of Indian remains.

Our surface hunting on this site was limited by vegetation but from the amount of material gathered here in the past, it is clear that this was an occupation area, probably of one major Indian group. The fluted point in the Hitchcock collection may represent the Paleo-Indian period and if so, is the first such evidence from this reservoir area. The other artifacts — gorgets, celt, points and scrapers — may imply an Early to Middle Woodland industrial complex. The curved, hafted side scraper was unique when discovered, but two other examples have since been found. Local tradition places a burial mound somewhere in the vicinity, possibly that indicated on map 2.

Site No. 25 on Map 1

36Me25 (Hitchcock, no. 27) is a small site on the first bottom south of the Shenango about one-half mile west of Me17. It would be completely covered by the reservoir at full pool. Hitchcock has a small collection from here, and surface hunting by the survey party produced one triangular point, chert flakes, 45 grit- and 5 shell-tempered potsherds. Some of the grit-tempered sherds were thick and fabric-marked, but most were thin with cordmarking, smooth or incised-over-cord surface finish. They probably indicate a late period occupation, but one different from that at 36Me17.

Site No. 26 on Map 1

36Me26 is an extensive camp area and extends from the edge of Pymauning Creek up-slope about 600 yards. The reservoir would cover the lower part of this site. C. A. Onstott, the landowner, has a collection gathered from the site during the past 50 years, and selected items from it are shown in figures 23-26. Most of the items found here appear to belong in the Archaic period, with the exception of the gorgets and triangular points. One of the hafted, semi-lunar side scrapers like that from Me24 came from this site. Surface hunting produced only a few pieces of chert and no area of intensive occupation was located, but vegetation prevented adequate search in all areas.

Site No. 28 on Map 1

36Me28 Some three-fourths of a mile east of 36Me17 and at the same elevation is a camp area which produced evidence of having been an Archaic period workshop. Like Me17, this site also would be completely flooded. In a fairly restricted area near the crest of the second terrace, surface hunting produced many chert flakes, several blank or partly worked pieces of banded slate, half of a "pick" type bannerstone and a fragment of a "butterfly" type. The "pick" half may fit the half illustrated in Hitchcock's collection from adjoining Me17; it is certainly the same type. The site is particularly interesting because of the large amount of banded slate material, much of which was evidently used in the manufacture of bannerstones.

Site No. 29 on Map 1

36Me29 (Hitchcock, no. 20) is a small campsite on the east bank of the Shenango about one and one-fourth miles above 36Me24. It would be flooded at full pool. Surface hunting was restricted because of a crop planted on the site, but chert flakes were found and Hitchcock reported finding artifacts here in the past.

ADDITIONAL MATERIALS

There are, no doubt, other sites in the reservoir area, but those listed above are the major ones which were accessible to us in the time available. In addition to the collections above, a large assemblage of specimens belonging to Prof. Harry Kane and obtained in Pymatuning Creek valley, was examined and photographed.

This collection includes, among other things, 2 full-grooved axes; several adzes and celts; 2 unfinished boatstones or bar spearthrower weights; 1 bird-stone head; 1 tubular, 1 bi-pennate, 1 pick, and 1 unfinished crescent bannerstone; 12 gorgets, mostly rectangular pendant types, one of which had "1720" scratched on it; 1 flake knife of local chert and 1 well-made hafted semi-lunar side scraper like those found at Me24 and Me26.

SUMMARY OF FINDS

A brief summary of some of the distinctive artifacts from the Shenango area shows that seven tubes of Ohio fireclay were seen, two of which were of the blocked-end variety, the other pieces being open-end fragments. One pottery tube fragment was recorded. Pottery types ranged from a Vinette I variant that appeared on one site, through possible Middle Woodland, smoothed grit-tempered varieties on three sites, to Late Prehistoric grit- and shell-tempered cordmarked and incised wares on three sites.

Various types of gorgets were seen, the most numerous being the simple two-hole rectanguloid and two-hole reel-shaped variations. Pendant and expanded center types were also recorded.

At least eight kinds of bannerstones were examined; they are considered to be spearthrower weights in most cases. The tubular type was most numerous with the knobbed (?) lunate, pick, and crescent types following closely in popularity. Other varieties recorded were butterfly, flattened ball, lunate, and miniature axe. A wide variety of projectile points was recorded, with stemmed and notched types preponderant on most sites.

RECOMMENDATIONS

Interpretations of the significance of the described archeological materials have been included in the preceding sections. Conclusions as to time period, recommendations and plans for action are summarized in table 1.

Three sites (33Tr4, 36Me16 and 36Me17) are outstanding in the probable span of time they cover and the apparent richness of the remains. All three should be test excavated to determine depth of deposit and to locate concentration areas. One, 36Me17, is productive and important enough to warrant full-scale excavation, preferably following preliminary testing. The UOVAS has definite plans to test 36Me17 and 36Me16 in 1953 or 1954. Site 33Tr4

merits testing even though the most important part may lie outside the reservoir.

The historic Delaware town, 36Me11, is an important site and should be tested and probably fully excavated if significant deposits such as a cemetery can be located. The other historic site, 36Me15, may be worth testing to search for additional burials.

SITE	PERIODS REPRESENTED						RECOMMENDATIONS			UOVAS PLANS		
	<i>Paleo-Indian</i>	<i>Archaic</i>	<i>Early Woodland</i>	<i>Middle Woodland</i>	<i>Late Prehistoric</i>	<i>Historic</i>	<i>More Surface</i>	<i>Test Excavation</i>	<i>Full Excavation</i>	<i>More Surface</i>	<i>Test Excavation</i>	<i>Full Excavation</i>
33Tr3					?		X					
33Tr4		X	X	X	X		X	X		X	?	
36Me11					?	X		X	?		?	
36Me15						X		?				
36Me16		X	X	X	?		X	X	?	X	X	?
36Me17		X	X	X	X		X	X	X	X	X	?
36Me24	?		X	X			X	X		X		
36Me25				?	X		X	X		X		
36Me26		X	X		?		X			X		
36Me28		X					X	?		X		
36Me29							X					

TABLE 1

CONCLUSIONS

From the information gathered on the survey and presented in this paper, it is possible to reconstruct a picture of the human occupation of this part of the Shenango Valley. Paleo-Indian hunters of the mammoth and other extinct animals probably moved into this area from the west about 6000-8000 B.C. Small scattered bands of people using the spearthrower with a fluted spear point, like that found on 36Me24, characterized the period. During the next several thousand years general cultural conditions remained the same with, however, some changes in stone tool types. The fluted spearpoint probably developed into the well-made lanceolate point, and near the end of this late Paleo-Indian stage, stemmed and notched points came into vogue.

By 2000-3000 B.C. groups of Archaic period hunters, using the spearthrower with stone weights, the adze, the fully grooved axe, and possibly using dogs, were well established on recurrently used camps. The making of polished stone gorgets and highly polished stone tubes for smoking or other uses, perhaps growing out of the bannerstone-working tradition, marks the beginning, about 1000 B.C., of a new period tentatively designated as Early Woodland. This period is not yet well known in this area and may prove to be indistinguishable locally from the following Middle Woodland period. General Woodland characteristics are: presence of stone tubes and polished gorgets; first development of pottery (including tubes); and beginning of a ceremonial concern for the dead, as reflected in burial mounds, in the use of rare materials such as mica and native copper, and in the widespread utilization of Flint Ridge material, especially in "cache blades" and flake knives. There was evidently a gap in occupation of the area, or at least a marked cultural change about 1000 A.D. when the Woodland periods closed.

By the time of the Late Prehistoric period, farming and village life were well established and elaborate concern for the dead had disappeared. Similarities in ceramics indicate cultural contact with occupants of the Monongahela and lower Allegheny valleys. Stockaded villages, probably the result of inter-tribal warfare, were numerous in southwestern Pennsylvania, present in northwestern Pennsylvania, and may have occurred in the Shenango area. These people developed local cultural variations during the years up to the coming of the Europeans, and some of them may have been the Iroquoian-speaking "Erie."

With the coming of the Historic period this area was certainly involved in the struggle for power among the Iroquois, Delaware and Shawnee. A late vestige of the people of this time remains at 36Me11 and the Me15 grave.

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Fig. 1. TERRY AND HARRY ALLEN COLLECTION OF CHERT ARTIFACTS FROM 33Tr4
a. drills b. bunts c. triangular points d. stemmed points e. side-notched points
f. corner-notched points g. leaf-shaped points h. blades

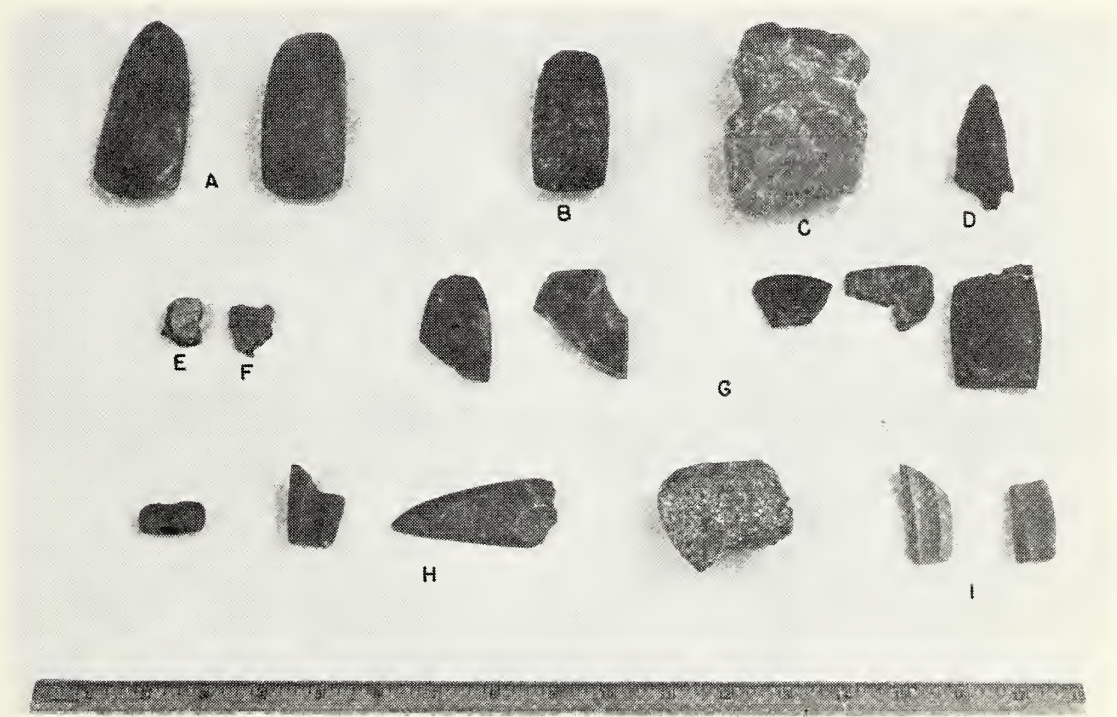


Fig. 2. TERRY AND HARRY ALLEN COLLECTION FROM 33Tr4
a. beveled adzes b. granite celt c. full-grooved igneous axe d. chert flake side
scraper e. thick, grit-tempered, cordmarked-on-both-surfaces potsherd f. thin,
grit-tempered incised potsherd g. gorget fragments (3 on right are of cannel coal)
h. bannerstones (axe, tube, pick and crescent types, from left to right) i. tube
fragments (left is Ohio fireclay, right is fine-grit-tempered pottery)



FIG. 3. FLINT, GLASS AND METAL ARTIFACTS FROM HISTORIC BURIAL AT 36ME15
(Photograph by John Witthoft)

- a. gun flints b. seed beads c. vanity case full of wedge-back and pewter buttons
and silver scrap d. projectile points, probably not associated

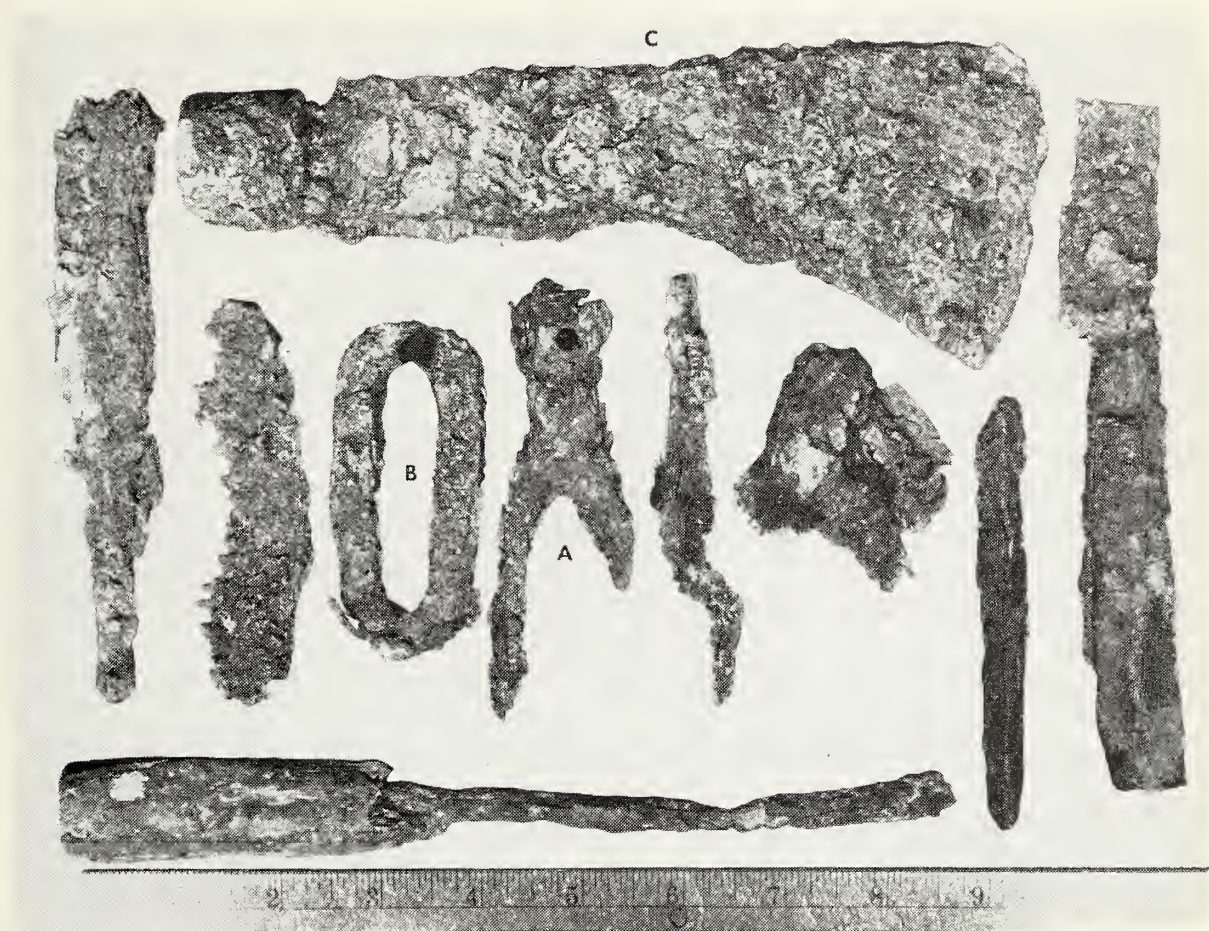


FIG. 4. METAL ARTIFACTS FROM HISTORIC BURIAL AT 36ME15
(Photograph by John Witthoft)

a. bullet mold b. strike-a-light c. pipe tomahawk

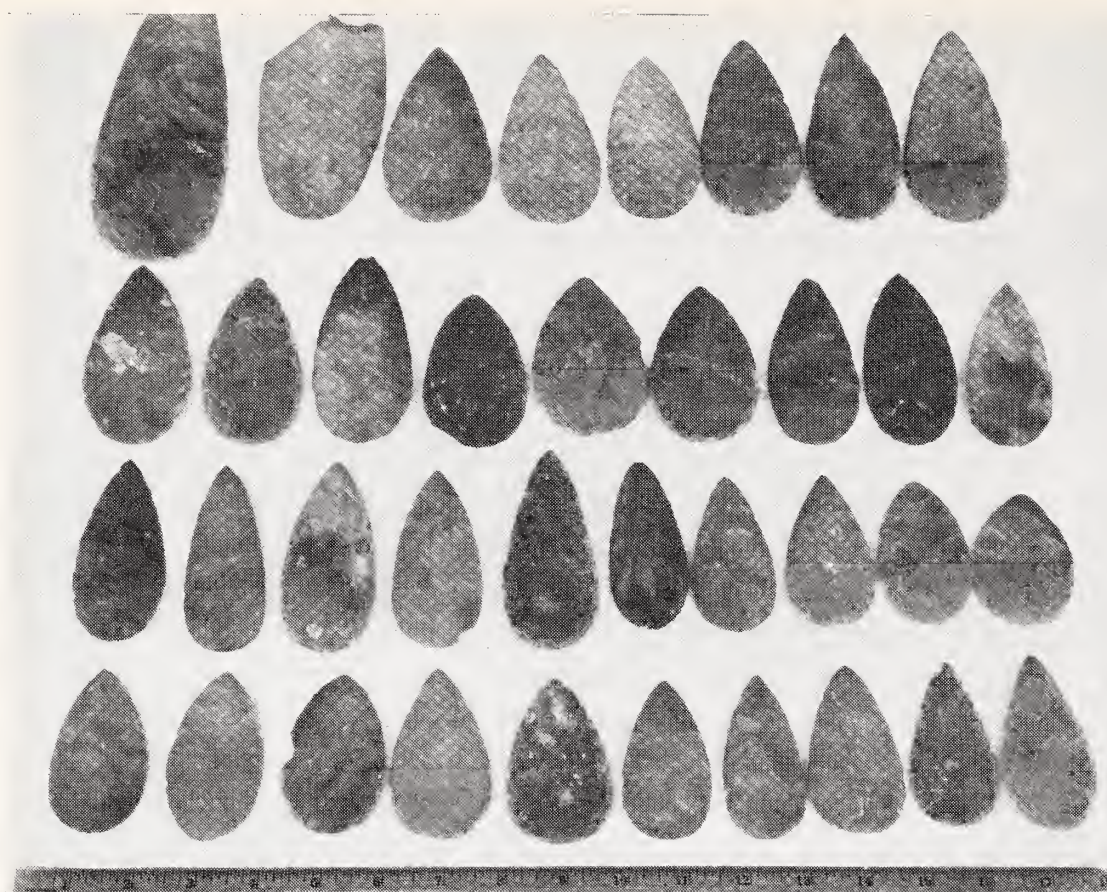


Fig. 5. ELLIS J. STEWART COLLECTION OF FLINT RIDGE CACHE BLADES FROM 36Me16



Fig. 6. ELLIS J. STEWART COLLECTION OF IGNEOUS STONE ARTIFACTS FROM 36Me16
a. full-grooved axes b. adzes c. beveled adze d. celts

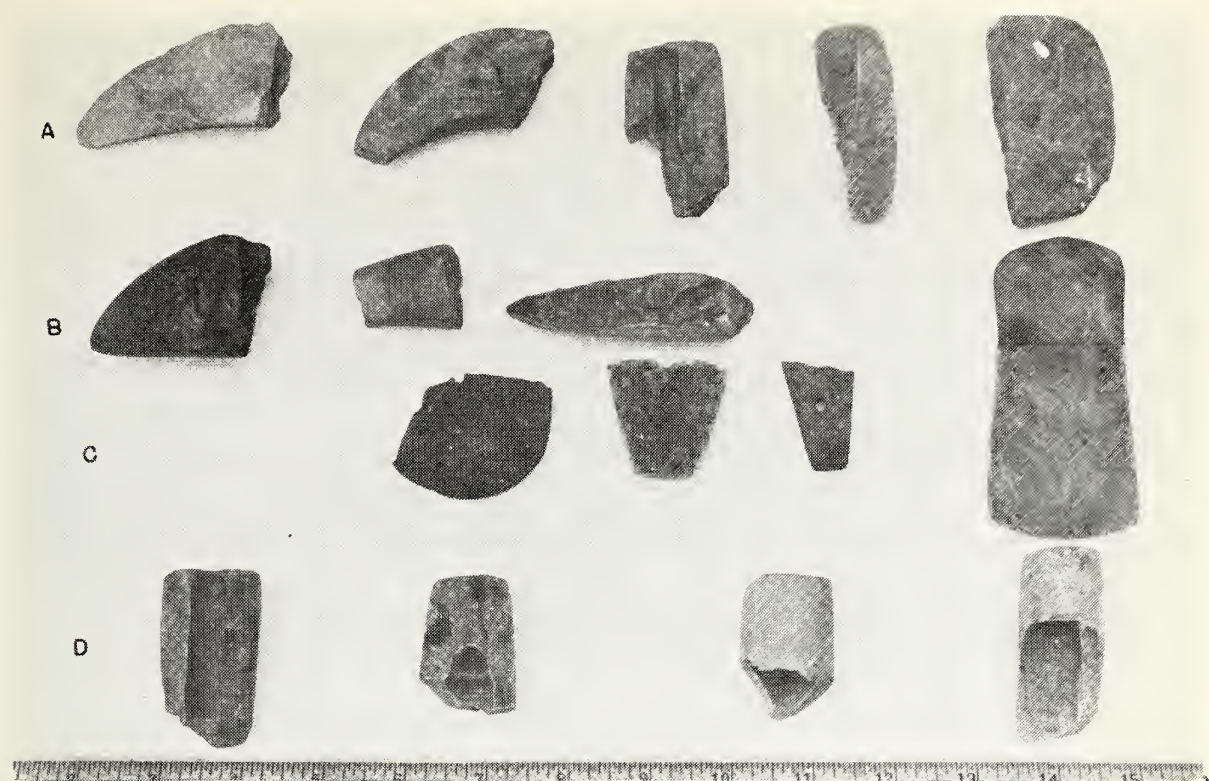


Fig. 7. ELLIS J. STEWART COLLECTION OF POLISHED STONE ARTIFACTS FROM 36Me16
 a. bannerstones (2 crescent, 3 flattened tube) b. bannerstones (2 crescent, 1 pick)
 c. banded slate gorgets d. Ohio fireclay tube fragments (2 open-ends, 2 blocked-end)

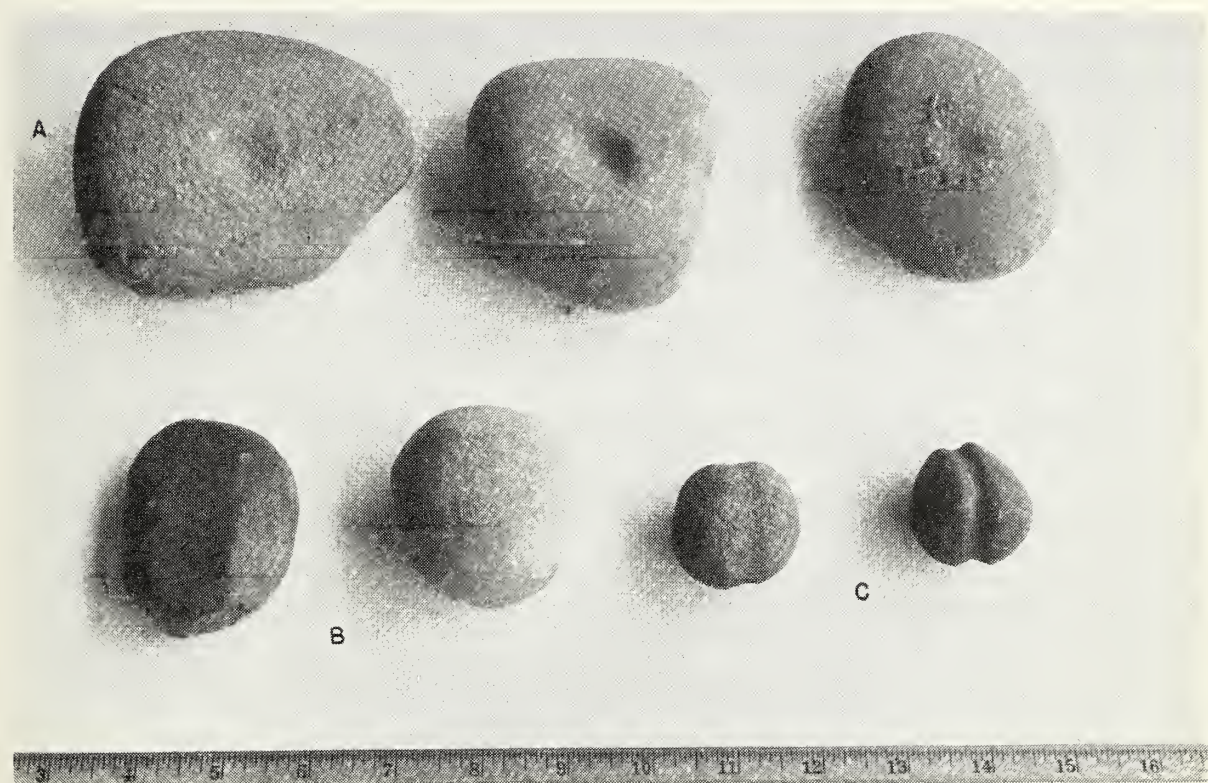


Fig. 8. ELLIS J. STEWART COLLECTION OF GROUND STONE ARTIFACTS FROM 36Me16
 a. bi-pitted stones b. hammerstones c. grooved stones (weights?)



Fig. 9. ELLIS J. STEWART COLLECTION OF SIDE-NOTCHED PROJECTILE POINTS
FROM 36Me16



FIG. 10. ELLIS J. STEWART COLLECTION OF CORNER-NOTCHED POINTS FROM 36Me16

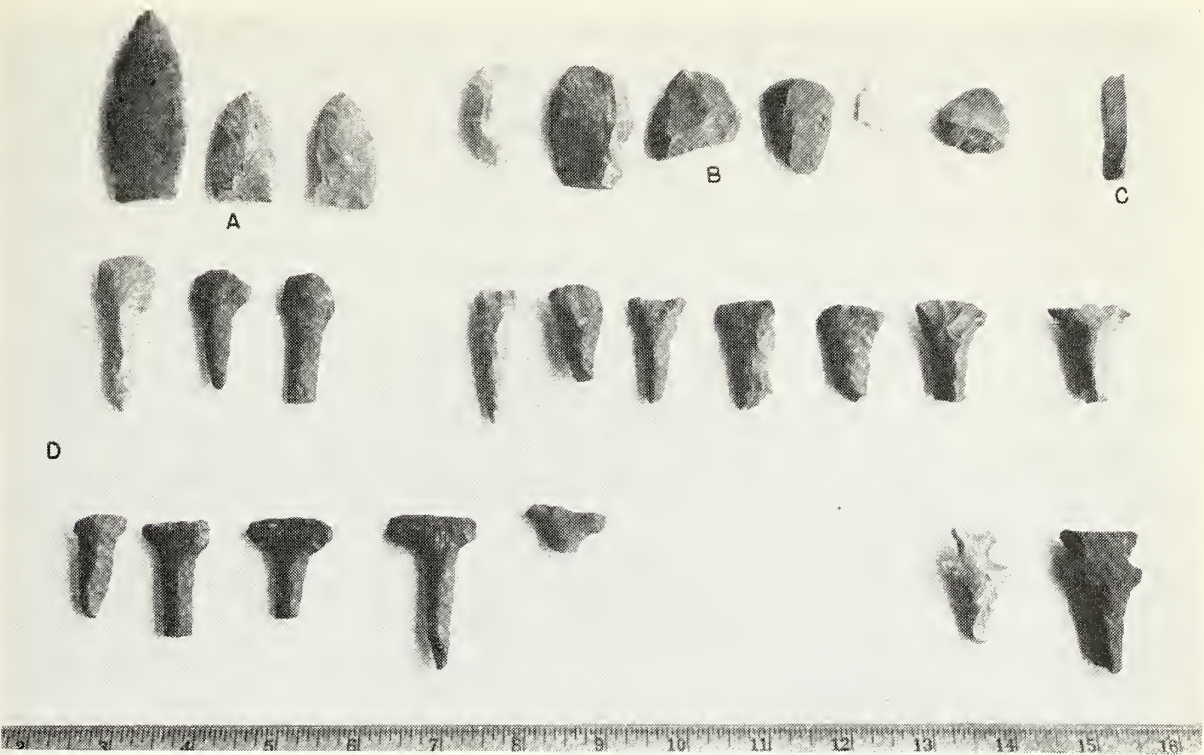


Fig. 11. ELLIS J. STEWART COLLECTION OF CHERT ARTIFACTS FROM 36Me16
a. lanceolate points b. plano-convex end and side scrapers c. Flint Ridge flake knife d. drills



Fig. 12. ELLIS J. STEWART COLLECTION OF STEMMED POINTS FROM 36Me16



FIG. 13. ELLIS J. STEWART COLLECTION OF BIFURCATED-BASE POINTS FROM 36Me16

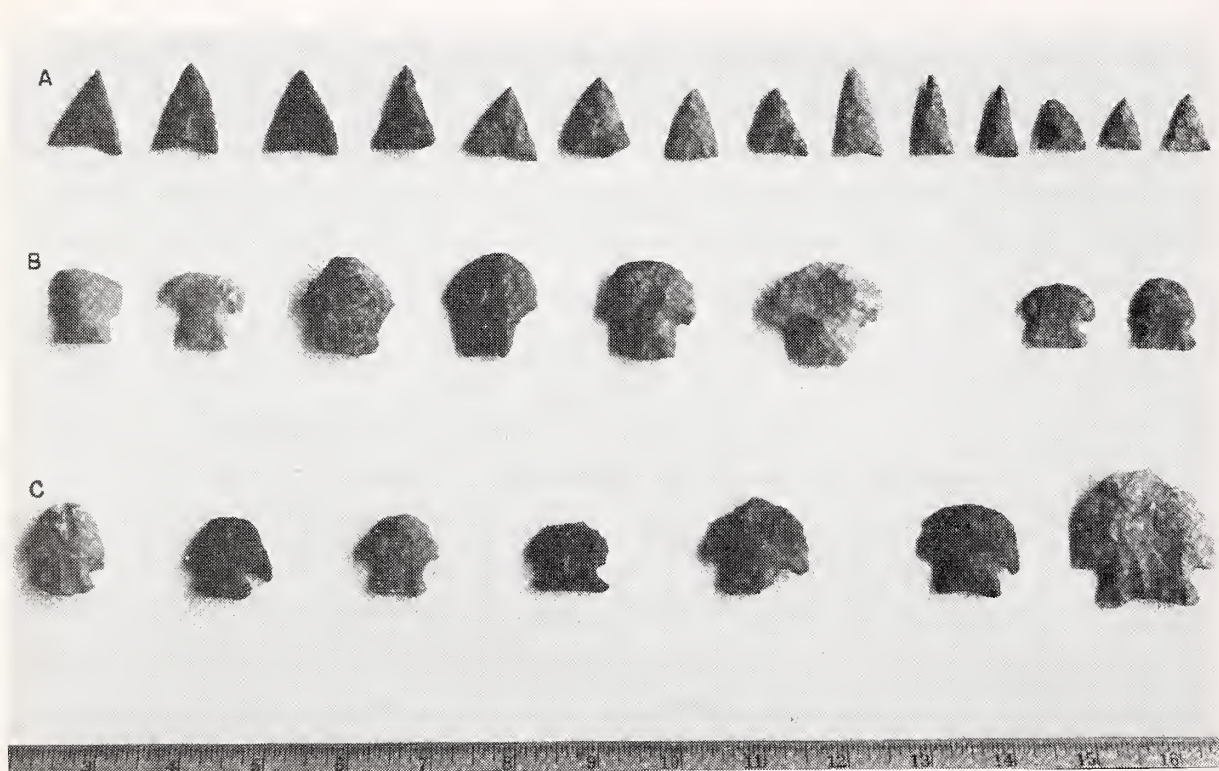


Fig. 14. ELLIS J. STEWART COLLECTION OF CHERT ARTIFACTS FROM 36Me16
a. triangular points b. bunts c. bunts

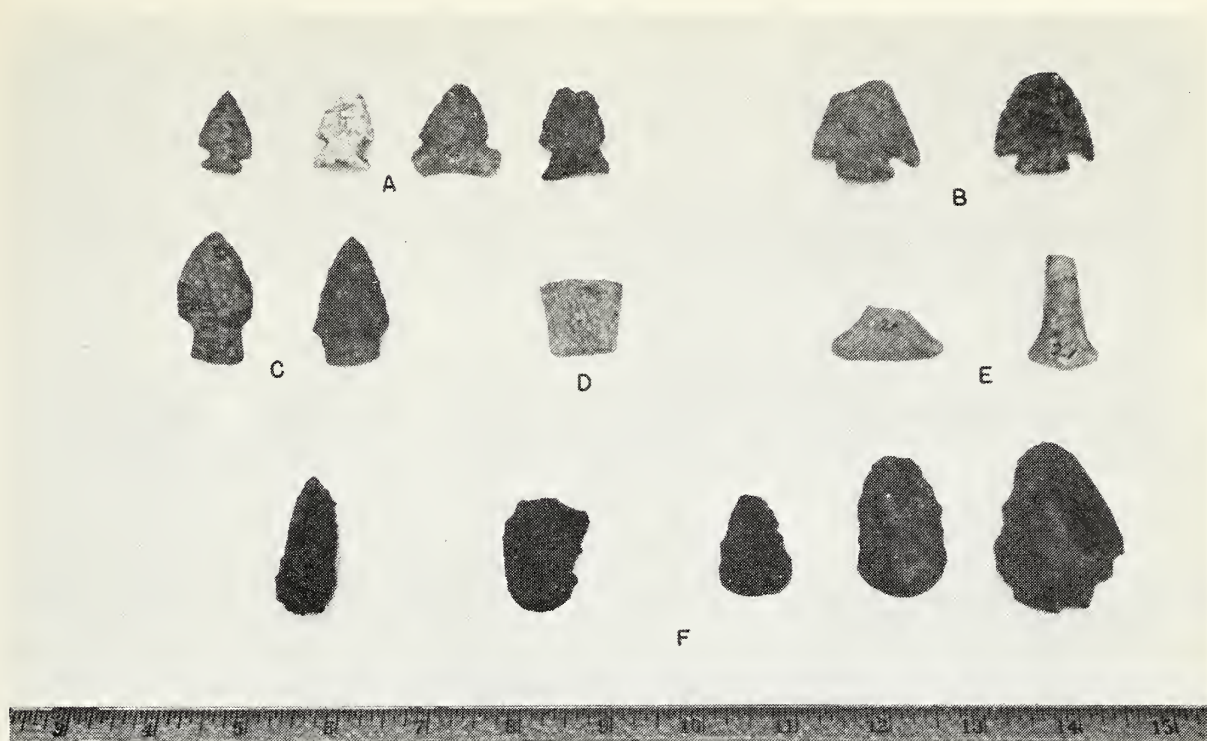


Fig. 15. WALTER J. HITCHCOCK COLLECTION OF CHERT ARTIFACTS FROM 36Me16
 a. side-notched points b. corner-notched points c. stemmed points d. lanceolate
 point base e. drill bases f. plano-convex snub-nose end scrapers

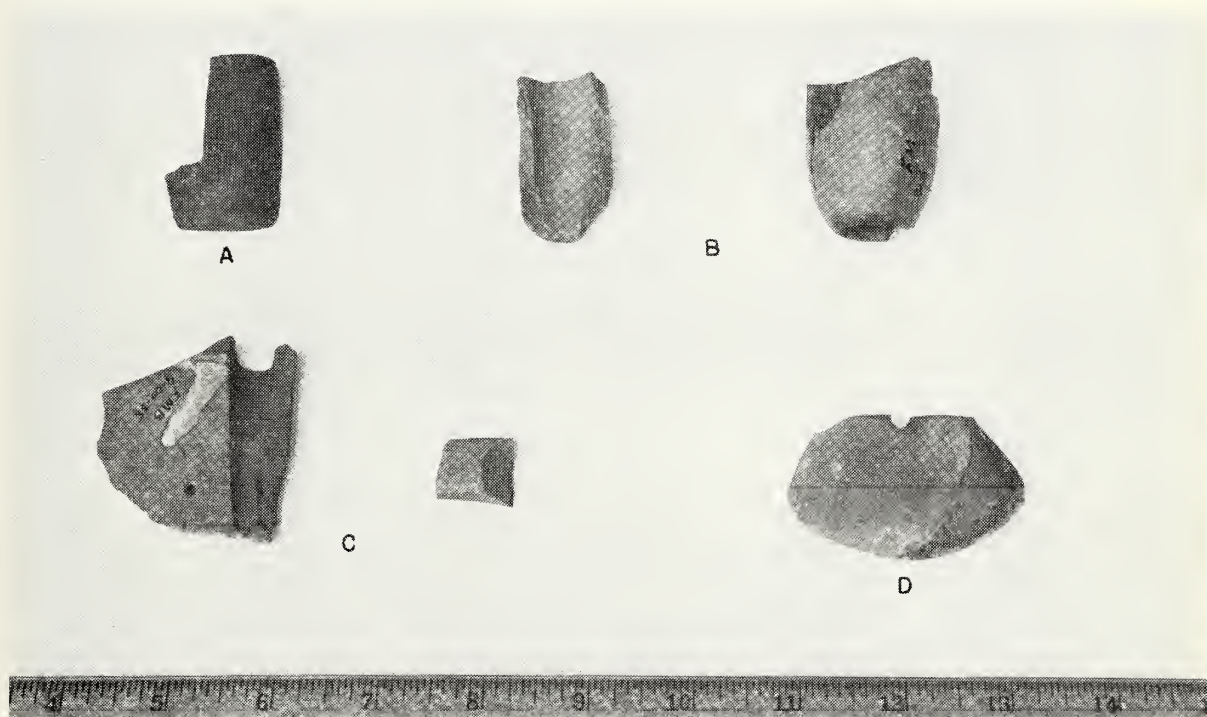


Fig. 16. R. K. CARTWRIGHT COLLECTION OF POLISHED STONE ARTIFACTS FROM 36Me17
 a. sandstone elbow pipe b. Ohio fireclay open-end tube fragments c. banner-
 stones (butterfly, lunate?) d. gorget fragment

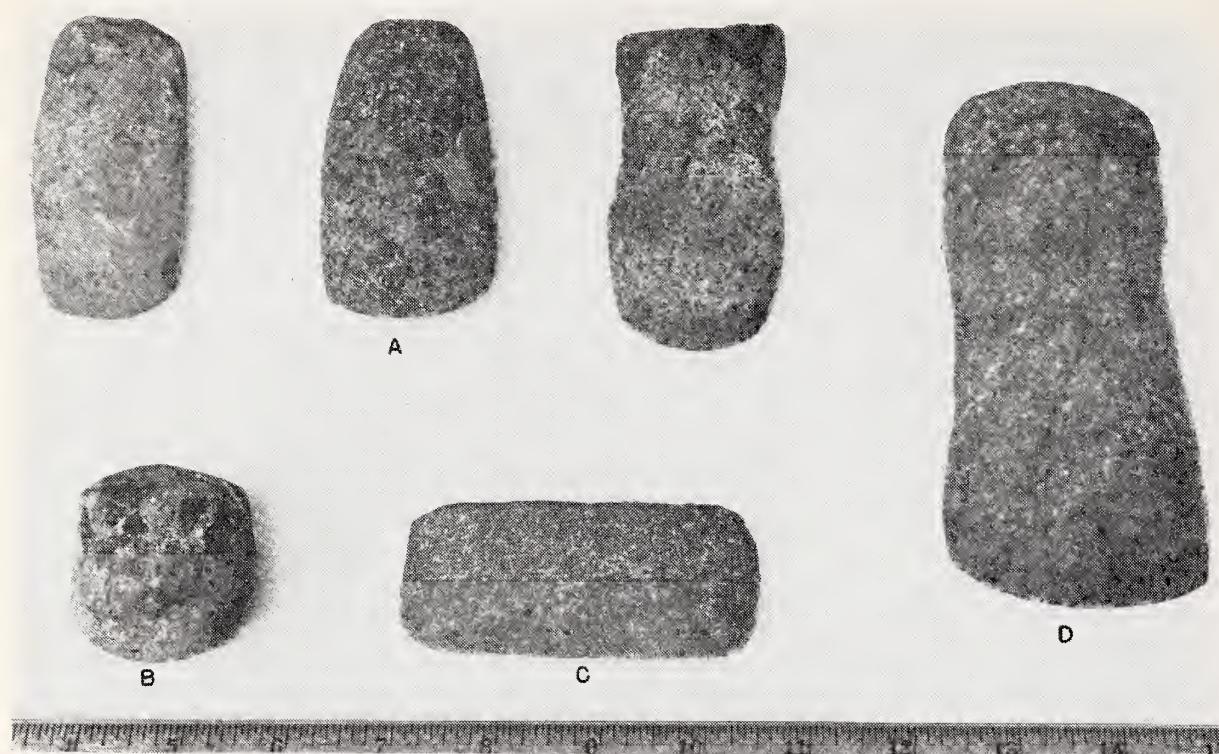


Fig. 17. R. K. CARTWRIGHT COLLECTION OF GROUND GRANITE ARTIFACTS FROM 36Me17
a. adzes b. hammerstone c. rough beveled adze d. celt

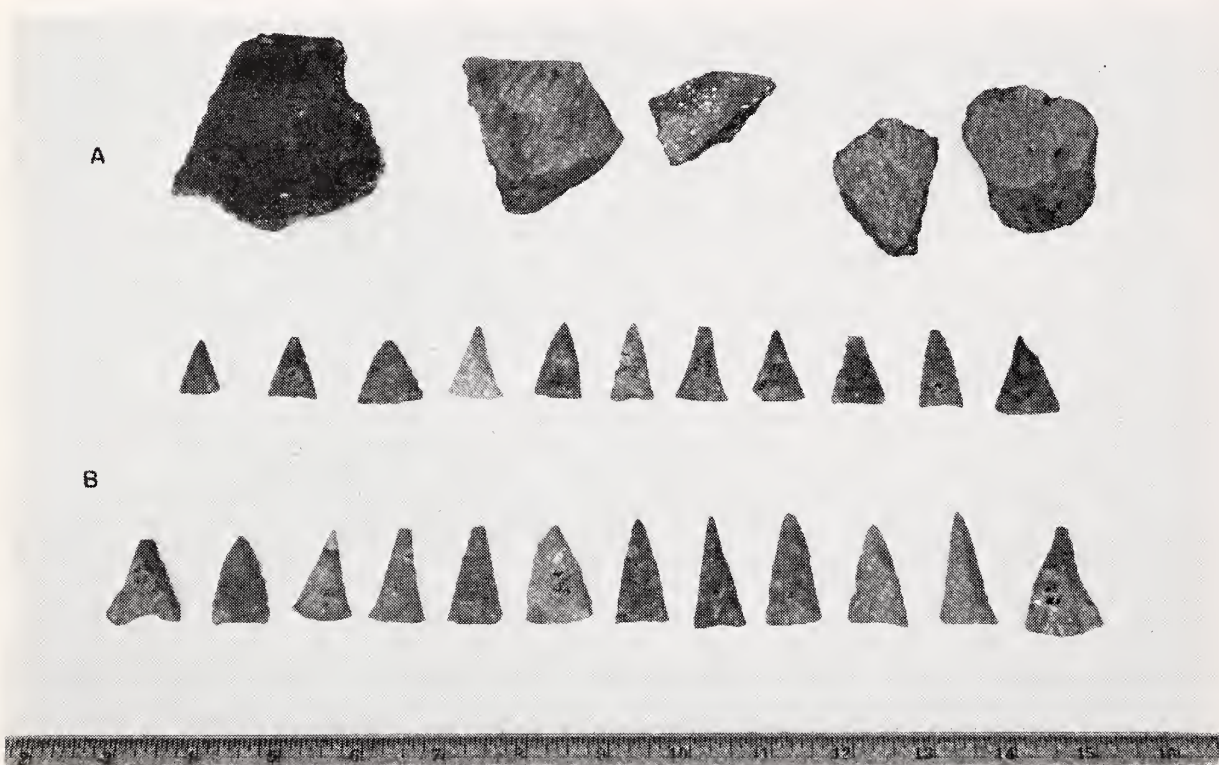


FIG. 18. R. K. CARTWRIGHT COLLECTION FROM 36Me17
a. shell-tempered potsherds b. triangular points

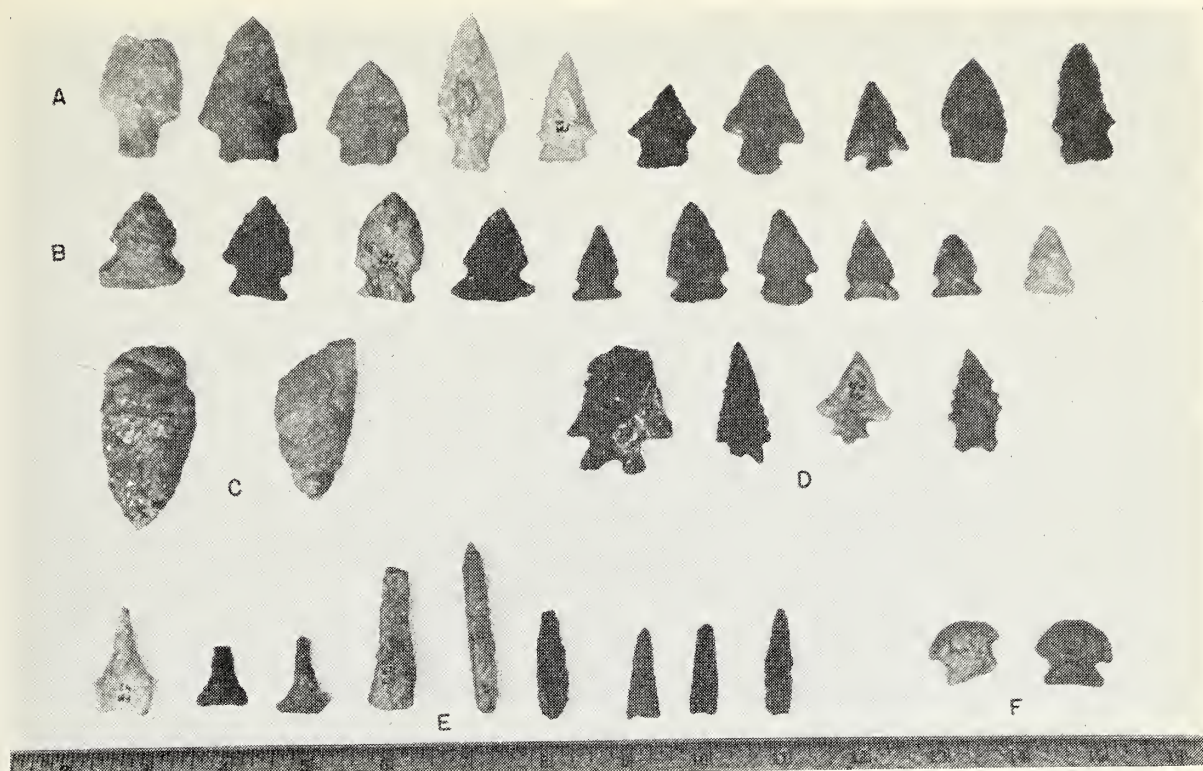


Fig. 19. R. K. CARTWRIGHT COLLECTION OF CHERT ARTIFACTS FROM 36Me17

a. stemmed points b. side-notched points c. side scrapers
d. bifurcated-base points e. drills f. bunts

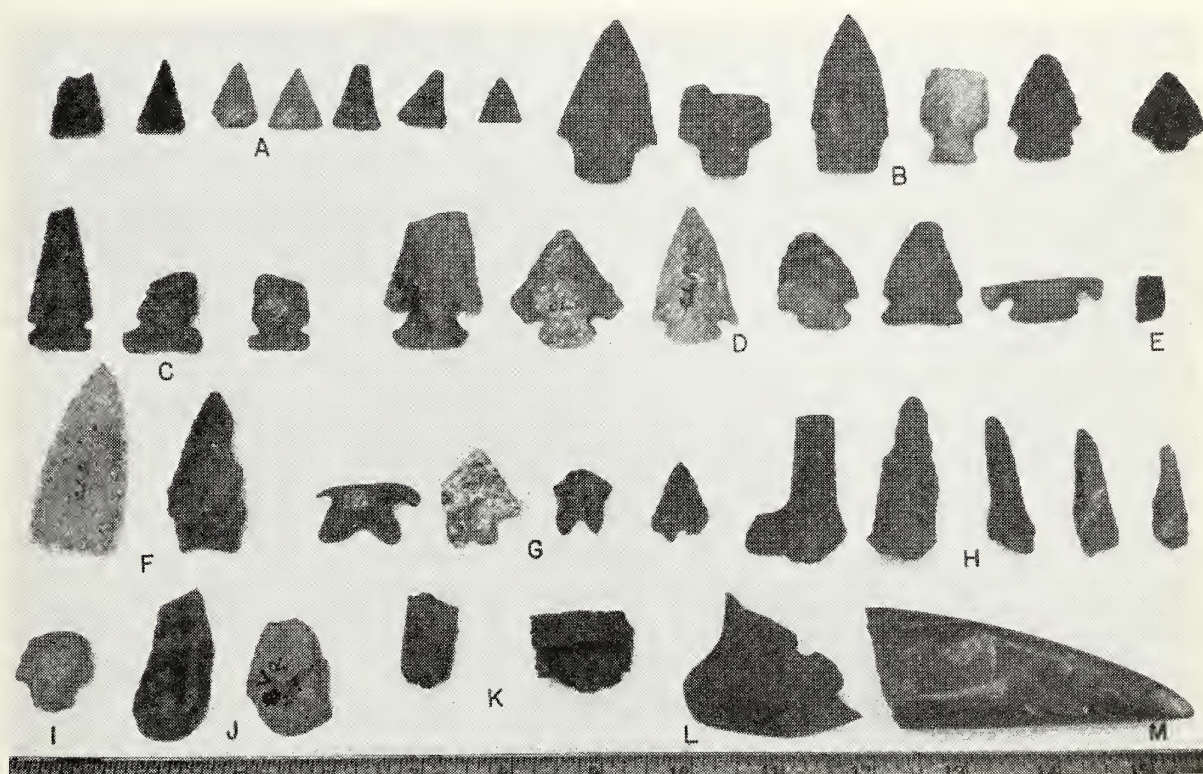


FIG. 20. WALTER J. HITCHCOCK COLLECTION FROM 36Me17

a. triangular points b. stemmed points c. side-notched points d. corner-notched points
e. chipped rectanguloid f. lanceolate points g. bifurcated-base points
h. drills i. bunt j. plano-convex snub-nose end scrapers k. grit-tempered pottery pipe stem and rimsherd l. gorget fragment m. bannerstone fragment

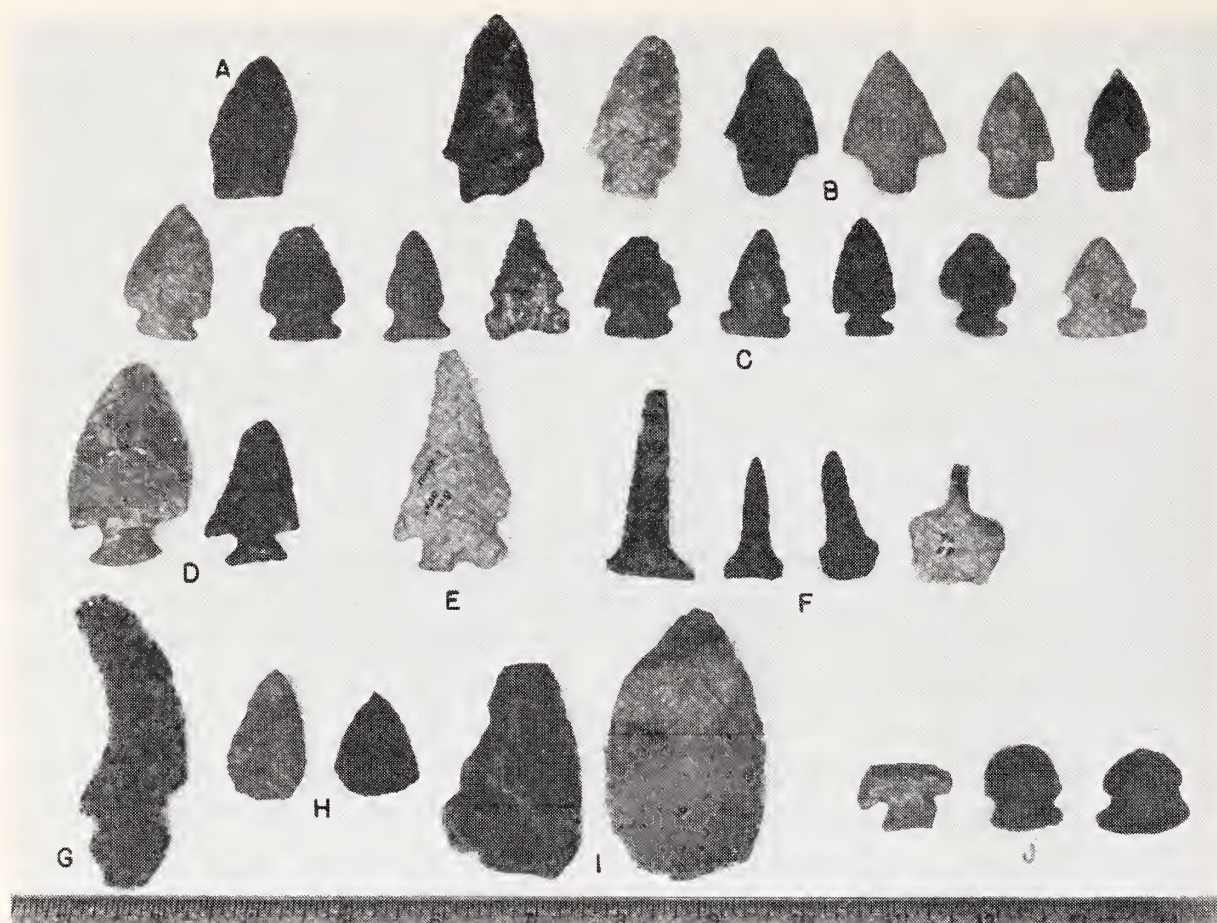


FIG. 21. R. K. CARTWRIGHT COLLECTION FROM 36Me24

- a. lanceolate point b. stemmed points c. side-notched points d. corner-notched points e. bifurcated-base point f. drills g. hafted semi-lunar side scraper h. plano-convex end scrapers i. side scrapers j. bunts

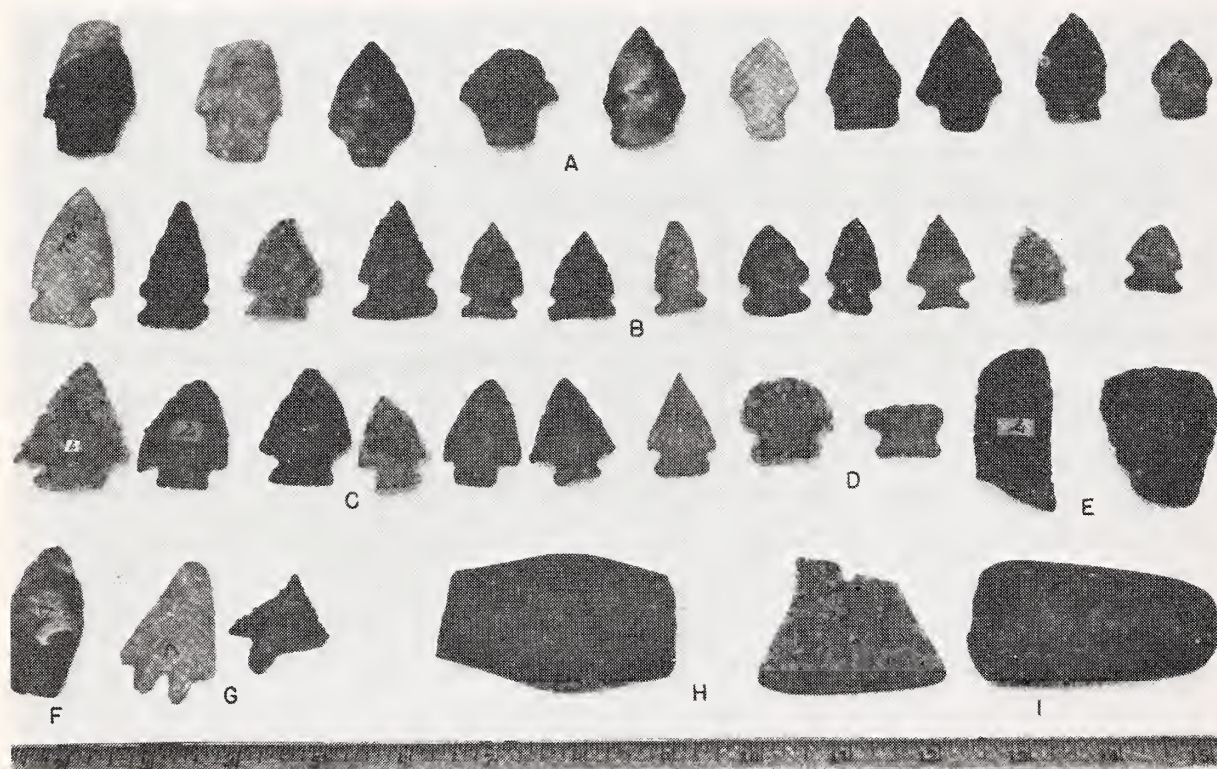


Fig. 22. WALTER J. HITCHCOCK COLLECTION FROM 36Me24

- a. stemmed points b. side-notched points c. corner-notched points d. bunts e. side and end scrapers f. fluted point g. bifurcated-base points h. gorgets i. adze



Fig. 23. C. A. ONSTOTT COLLECTION OF GROUND STONE ARTIFACTS FROM 36Me26
 a. full-grooved axe b. 4 adzes c. beveled adze fragment d. celts
 e. grooved stones (weights?)



Fig. 24. C. A. ONSTOTT COLLECTION OF POLISHED STONE ARTIFACTS FROM 36Me26
 a. gorgets b. boat (?) stones c. grooved stone (weight?) d. pendant gorgets
 e. bannerstones (flattened ball, lunate, crescent, tube)

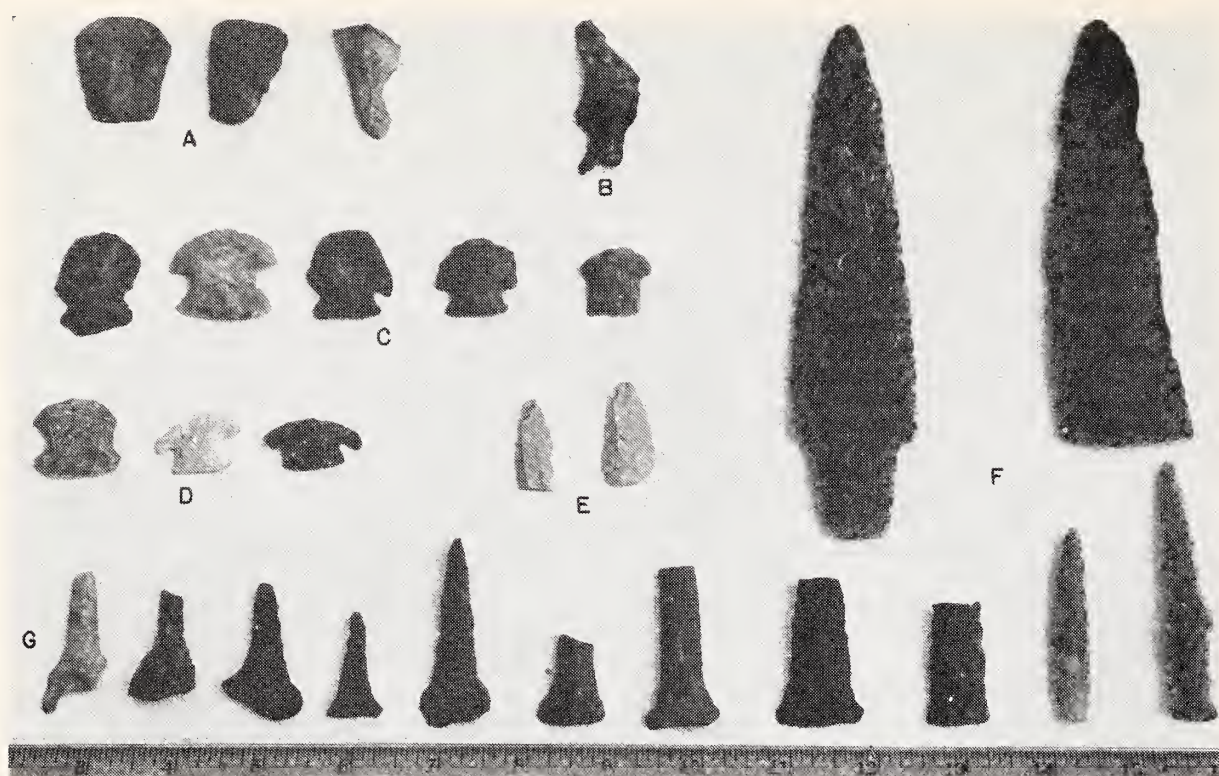


Fig. 25. C. A. ONSTOTT COLLECTION OF CHERT ARTIFACTS FROM 36Me26
 a. plano-convex end scrapers b. hafted semi-lunar side scraper c. bunts d. bunts
 e. Flint Ridge flake knives f. large knives g. drills

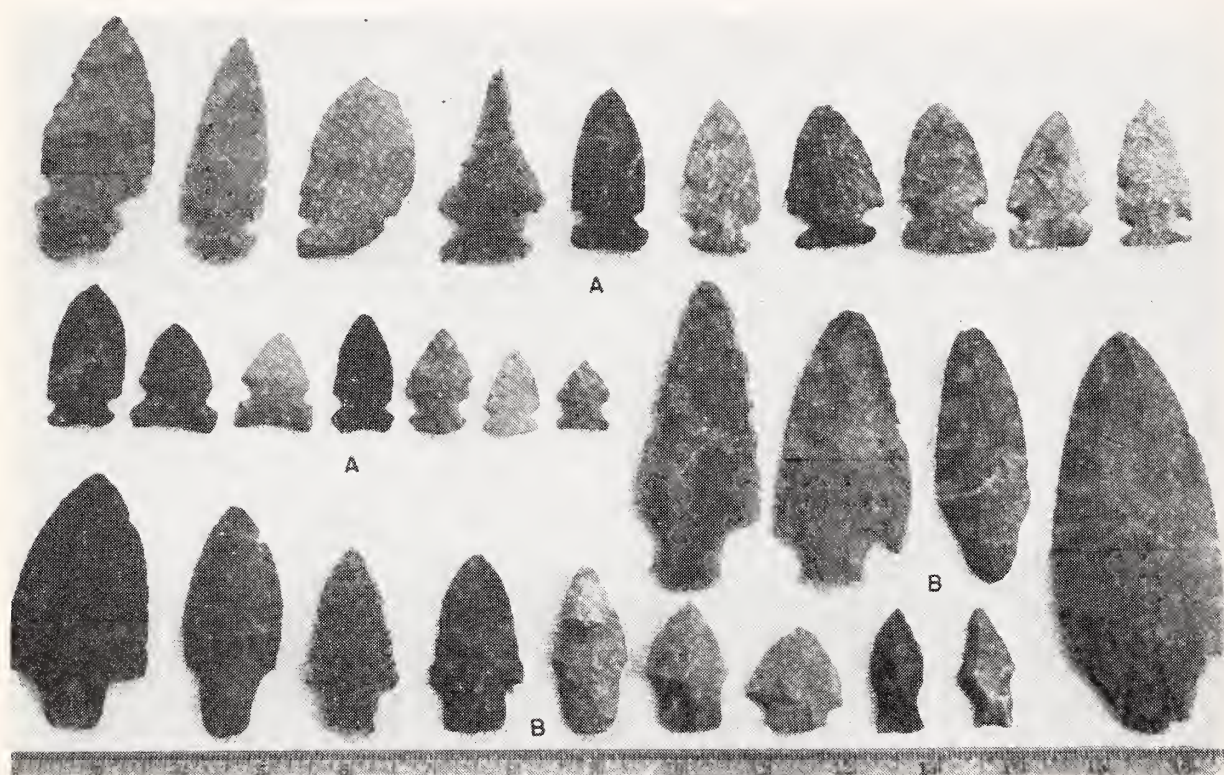


FIG. 26. C. A. ONSTOTT COLLECTION OF CHERT ARTIFACTS FROM 36Me26
 a. side-notched points b. stemmed points

ART. 4. STATUS OF THE SOUTH AMERICAN IGUANID LIZARD,
ENYALIUS COERULESCENS COPE

CARL GANS* AND P. E. VANZOLINI†

Cope (1876: 169) in his catalogue of the reptiles collected by Orton on his Amazonian trip lists two specimens of *Enyalius*. One of these, *Enyalius laticeps* (Guichenot), was placed in the new genus *Enyalioides* by Boulenger (1885: 112), who separated this genus from *Enyalius* on the basis of keeled infradigital lamellae and other minor characters. Cope also described the new species *Enyalius coerulescens* from the Orton collection, without, however, giving it a definite type locality other than the Amazon from Santarem to Peru. Since the time of the original description no additional records for the species have appeared in the literature, though on Cope's authority the form has since been cited several times. A revision of the *Enyalius catenatus* group currently in process makes it desirable to determine definitely the assignment of this form.

The original diagnosis of the species reads as follows:

A dentellated nuchal crest, a vertebral band of linear scales; no caudal crest; all subround in section. Head wide, muzzle parabolic, its entire surface including the supraorbital region covered with equal acutely tubercular scales. Three rows intervene between the superciliary rows; occipital scarcely distinct. Nostril pierced in a small round shield; nearer orbit than end of muzzle. Loreal region very short, with ten scales on a vertical line. Supraocular scales eighteen counting to nostril. Labials 11-11, a short series of distinct smooth infralabials. Auricular opening large. Dorsal scales very small, keeled, in transverse rows; abdominal scales larger, in cross series, interrupted on the middle line, keeled. The hind leg and wrist extend to front of orbit.

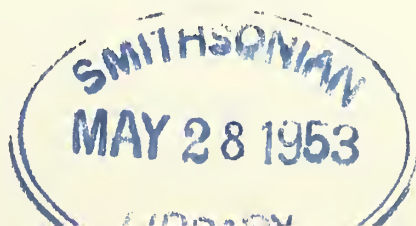
Color black, with numerous indistinct blue bands. Limbs, especially the forearm, and the sides of the neck, dark blue. Lower surfaces white, except throat and chin, which are blackish-blue.

	M.
Total length185
Length to vent072
Length to axilla034
Length to ear018
Length to orbit006

Width at anterior angle of orbit .009; apparently allied to the *E. brazilensis*, Lesson (Voyage Coquille Reptiles, Pl. I, fig. 3), but that species has a dorsal crest of erect scales.

*Research Associate, Carnegie Museum, Pittsburgh.

†Department de Zoologia, S. Paulo, Brasil.



After Cope's death the Orton collection was transferred to the Academy of Natural Sciences of Philadelphia, and Dr. E. R. Dunn has kindly furnished us with information regarding the fate of this material. All of these specimens were at one time sent to Dr. T. Barbour at the Museum of Comparative Zoölogy at Harvard College, where part of the collection was retained and the remainder returned to the Academy with Barbour's identifications. Here the material was never sorted out and the identifications were lost so that the exact disposition of any specimen from the original collection may no longer be determined with any degree of exactitude.

There are two specimens extant, both of which appear to possess almost equally good claims to the designation of type. These are ANS 11382 and MCZ 12438, both of which are labeled *Enyalius coerulescens* (*caerulescens* in the case of the MCZ specimen*). Catalogue entries for both specimens refer them to the Orton collection, with the locality being indicated as Peru for the MCZ specimen, though it is possible that this may have been added subsequently. It is of interest to note that the ANS specimen is not listed as a type in the Academy's catalogue although this is the case for several other specimens from the Orton collection.

The MCZ specimen is a male with a body length of 13 cm. (the partially missing tail measures another 4 cm.), which would tend to eliminate it from consideration as the type, though both the remnants of the color pattern and the scutellation are in good agreement with the description of the type. The specimen possesses keeled infradigital lamellae, a fringed nuchal crest and two femoral pores.

The ANS specimen is almost totally disintegrated, the jar containing several large pieces, some bones and considerable "soup." The head is crushed and it and part of one front limb are held together by remnants of the integument, which clearly shows the black gular patch mentioned in the typical description. Both hind limbs and the tail are separated and badly crushed, but some of the toes still permit determination of the fact that they possess keeled infradigital lamellae. All other apparent scutellation characters agree with the description. While the specimen presents the impression of having been slightly larger than the measurements given by Cope, its condition makes such impressions inconclusive and for the above reasons it is felt that this is almost certainly the lizard used by Cope for his description.

Since both of these specimens show keeled infradigital lamellae, one of them in addition possessing the femoral pores always absent in *Enyalius*, they certainly belong to the genus *Enyalioides* rather than to *Enyalius*, and the name *coerulescens* must hence be removed from the roster of the latter genus. Unfortunately its exact status within the genus *Enyalioides* cannot

*Boulenger's (1885: 120) incorrect spelling, "*caerulescens*," appears to have been copied by several subsequent authors.

yet be ascertained beyond doubt; and the badly confused record has prevented any more definite statement as to whether Cope believed both of these specimens to be *Enyalius coerulescens*, and (if not) which one formed the basis for his record of *Enyalius laticeps*. Comparison with other specimens of *Enyalioides* indicates that *coerulescens* most closely resembles *E. l. laticeps*, and appears to be a synonym of the latter. Settlement of this point will have to wait for a thorough review of the genus.

We wish to thank the authorities of the Museum of Comparative Zoölogy at Harvard College and the Academy of Natural Sciences in Philadelphia for access to the material of their respective collections.

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ART. 5. VARIATION OF THE SHAPES OF BIRDS' EGGS
WITHIN THE CLUTCH

by
F. W. PRESTON* AND E. J. PRESTON†

INTRODUCTION

In a previous paper, one of us (F. W. Preston‡) discussed a method of describing with precision the shapes of individual eggs. The size of the egg may be defined by its length (l or $2a$), and its ellipticity by the ratio of its (equatorial) diameter to its length ($2b/l$). In that paper ovateness is indicated by a constant, c_1 , and the biconical aspect by a second constant, c_2 . Alcids need a third constant, c_3 , but very few others do.

In the present paper we are not concerned with Alcids, since they lay only one egg to a clutch, and there is thus no comparison between the first and second or last eggs of a clutch.

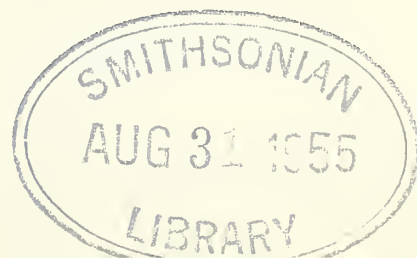
The problem of the present paper is to see whether there is any significant difference between the eggs of a clutch, and if so, what that difference is. A glance at almost any clutch of eggs will show that they are of different shapes, and perhaps of somewhat different sizes. They may differ also in degree of pigmentation, either of ground color or of spotting, or both, and again they may differ markedly in gloss. The question, therefore, can be formulated more precisely. Are there differences connected with the sequence of laying, and are the differences correlated in any way?

On a visit to the Pea Island Refuge, North Carolina, in June 1951 with L. B. Turner, the refuge manager, one of us saw a modest number of late nests of the Laughing Gull (*Larus atricilla*). Most of these contained only two eggs. Of the two, one was much more brilliantly pigmented and more pyriform (had a higher c_1 value) than the other, which was paler, duller, and more nearly elliptical. At the time we set down the more brilliant egg as the first of a clutch of two, but lacked proof of it. The assumption was based on observations of other species long antedating this occasion.

Several years ago Earl Schriver, in a conversation, said that the English Sparrow (*Passer domesticus*) typically lays five eggs, of which the last is less pigmented, more nearly elliptical (less ovate), and commonly smaller than the others. He described it as a "runt" egg, and believed it to be the last laid. Examination of a nest or two in the Frith (grounds of the Preston Laboratories, Butler, Pa.) indicated a possibility that he might be right, but an examination of 20 clutches at the Ohio State Museum, through the courtesy of Dr. E. S. Thomas, was inconclusive. Mr. Schriver also said that in his experience, the American Crow (*Corvus brachyrhynchos*) also tended to lay one "runt" egg. Again, an examination of museum clutches, this time at Carnegie Museum, Pittsburgh, failed to be conclusive. One of the difficulties with museum clutches is that the sequence of laying is unknown, and there is commonly some uncertainty as to whether the clutch is complete. An appeal for clutches where the sequence was known and in which it was certain that all eggs were present produced very little result. We had

*† Preston Laboratories, Butler, Pa.

‡ F. W. Preston. The shapes of birds' eggs. *The Auk*, April, 1953, v. 70, p. 160-182.



two clutches of Turkey Vulture eggs loaned us by Homer Price of Payne, Ohio, and one clutch of Black-crowned Night Heron by Laurel Van Camp of Genoa, Ohio. The latter showed that the last two eggs had a c_1 value lower than the first, while c_2 had a higher (negative) value for the second egg. With the help of a young friend, James Glenn, we measured a number of clutches of American Robin eggs in the Frith and nearby, but the labor was great for the results achieved. Accordingly, it became clear that what was wanted was a species which (1) nested colonially in large numbers, (2) nested on the ground so that the nests could be inspected quickly, (3) laid few eggs, preferably two but not more than three, and (4) preferably laid eggs about the size of those of the domestic fowl, which would lend themselves to easy contouring and measuring by the machine described in the previous paper and by a spherometer.

After studying various possibilities, it seemed to us that the best available material would be the nests of the Laughing Gull in southern New Jersey, near Stone Harbor. We were fortunate in having the help of Herbert H. Mills of the T. C. Wheaton Company, an excellent amateur ornithologist, and of Burritt Wright and his assistant, Stanley Quickmire, of the Audubon Center of South Jersey. This paper accordingly reports primarily on that material.

FIELD WORK

Larus atricilla nests by thousands on a vast acreage of saltings just west (inland) from Stone Harbor. The nests are often no more than two or three feet apart. It is possible to land readily in occasional coves, tie up the boat, and immediately begin operations among hundreds of nests. A rattan cane is pushed into the soft peat-muck beside a nest that contains only one egg. On that egg a large cross is marked with colored crayon, perhaps green. This is repeated until 50 nests are tagged on the first day.

The next day all tagged nests are re-examined, and if a second egg is found, it is marked with a big cross in red crayon. The third day a purple crayon is used, and so on. All 50 nests will not proceed to completion, but with luck, at least twenty complete clutches will be obtained. The complete clutch will usually contain three eggs. When the clutch is known to be complete in at least twenty nests, all of the eggs are contoured and spherometered. This can be done in the field if the weather is good.

Apart from clutches that were measured in the field, we found it necessary (because of rain) to collect about twenty for more detailed work at Butler. We had equally bad luck with weather in trying to perform the same experiment on eggs of the Common Tern and other species. Accordingly, the only species on which we have statistically significant data is the Laughing Gull. With this information worked out, we can get some further evidence from the others.

THE STATISTICS AVAILABLE

The sequence of laying in each nest is known. The nests are labeled A, B, C, etc., and the eggs in each nest are labeled in the sequence of their

laying as A1, A2, A3, for example. When there are only two eggs, they are called U1 and U2 (for example) though, as will be shown later, they would better be called U1 and U3, or U2 and U3.

After measuring, profiling, and computing, we have the following characteristics available for statistical analysis:

(1) length l , (2) maximum diameter, here called B , (3) equatorial diameter, here called $2b$, in accordance with the previous paper, (4) the "cubage" lB^2 , a figure roughly proportional to the volume of the egg, (5) the ellipticity, $2b/l$, (6) the radius of curvature of the big, or blunt, end, R_B , (7) the radius of curvature of the small, or pointed, end, R_p , (8) the ratio of these radii R_p/R_B , (9) the constant, c_1 , or ovateness, as defined in the previous paper, (10) the constant, c_2 , the biconical term. These figures are tabulated in Table I, though in a different arrangement.

We also know, as above explained, that any egg labeled A, for instance, was laid by a particular bird (unless the birds parasitize each other) and that any egg with a different label (B, or C, for instance) was *not* laid by this particular bird, for all nests were contemporaneous, and we can not be dealing with the same bird on two different occasions.

The questions to be asked are as follows:

Eggs may differ from one another because they are laid by different individual birds; they may also differ according to whether they are first, second or third in the sequence of laying. They may differ for other reasons, perhaps many reasons, all lumped together in what follows, and classified as "error." In this sense, error includes any inaccuracies of measurement or computation and any variability due to any cause whatever, except the consequences of being laid by another parent or being of a different ordinal number in the clutch.

The first question, then, is this. In what respects (i. e., in respect of which of the characteristics of Table I) do eggs differ according to their order in the clutch? More briefly, is the last egg of a clutch significantly different from the first?

The second question is: In what respects do all eggs of a clutch bear the imprint of their parent and differ from eggs of another parent?

These two questions require an "analysis of variance," partitioning the actual variance among three factors — (1) the ordinal number in the clutch, (2) the variation between parents, and (3) the "error" or all other causes of variability.

As a practical matter, the problems would be these: "Here are three eggs of a clutch. Pick out the first, second, and third in their sequence of laying."

Or, a much more difficult assignment: "Here are 60 eggs, comprising 20 clutches each of three eggs, all shuffled. Pick out all the eggs that were the last in a clutch. Also sort the eggs into the 20 original clutches; i. e., identify the parentage of each egg."

There is a still more difficult problem: "Here are 60 eggs (or 600) picked at random from a large number of nests of a single species of bird. Determine the most probable clutch size of the species."

TABLE I

(Values of B , R_B and R_P are in inches.)

Egg	Length l (inches)	Max. width B ($=B$ max.)	R_B	R_P	Ovateness c_1	Biconicalism c_2	Cubage lB^2 (cu. in.)	R_P/R_B	Equatorial diam. $2b$ (mm.)	Ellipticity $2b/l$
A1	2.225	1.565	0.612	0.298	0.193	-0.105	5.454	0.486	39.0	0.688
A2	2.110	1.554	0.715	0.337	0.182	-0.057	5.099	0.471	38.9	0.723
A3	2.136	1.513	0.646	0.301	0.216	-0.083	4.888	0.465	37.8	0.701
B1	2.158	1.507	0.721	0.288	0.240	-0.036	4.903	0.400	37.5	0.689
B2	2.110	1.509	0.647	0.358	0.164	-0.068	4.807	0.554	38.1	0.712
B3	2.102	1.438	0.555	0.340	0.140	-0.048	4.346	0.612	36.2	0.679
C1	2.175	1.581	0.726	0.373	0.206	-0.083	5.437	0.514	39.6	0.722
C2	2.055	1.557	0.707	0.372	0.178	-0.063	4.985	0.525	39.0	0.750
C3	2.165	1.540	0.628	0.375	0.143	-0.104	5.132	0.597	39.0	0.711
D1	2.230	1.608	0.661	0.318	0.187	-0.099	5.770	0.482	40.4	0.713
D2	2.152	1.552	0.686	0.286	0.212	-0.102	5.184	0.417	38.9	0.711
D3	2.168	1.538	0.656	0.369	0.176	-0.046	5.131	0.562	38.6	0.702
E1	2.226	1.565	0.721	0.404	0.159	-0.028	5.452	0.561	39.2	0.696
E2	2.203	1.540	0.645	0.396	0.149	-0.058	5.226	0.614	38.7	0.696
E3	2.184	1.535	0.557	0.360	0.123	-0.115	5.151	0.647	38.9	0.702
G1	2.115	1.606	0.723	0.294	0.248	-0.108	5.707	0.407	39.8	0.713
G2	2.201	1.616	0.709	0.310	0.214	-0.130	5.749	0.437	40.2	0.724
G3	2.065	1.599	0.714	0.332	0.203	-0.117	5.278	0.465	40.0	0.773
H1	2.180	1.567	0.701	0.399	0.188	-0.020	5.358	0.569	39.0	0.709
H2	2.132	1.545	0.689	0.360	0.188	-0.069	5.090	0.522	38.6	0.721
H3	2.149	1.476	0.647	0.359	0.168	-0.018	4.683	0.555	37.1	0.680
I1	2.159	1.543	0.701	0.417	0.156	+0.008	5.141	0.595	38.7	0.707
I2	2.184	1.563	0.677	0.330	0.207	-0.098	5.335	0.488	39.1	0.708
I3	2.166	1.512	0.594	0.336	0.161	-0.070	4.952	0.566	38.0	0.691
J1	2.226	1.523	0.551	0.368	0.172	-0.057	5.164	0.668	38.1	0.679
J2	2.060	1.538	0.677	0.373	0.154	-0.034	4.873	0.550	38.6	0.739
J3	2.056	1.493	0.612	0.321	0.155	-0.095	4.587	0.525	37.6	0.723

K1	2.121	1.551	0.688	0.373	0.177	−0.053	5.106	0.543	38.8	0.725
K2	2.194	1.543	0.660	0.331	0.203	−0.059	5.227	0.501	38.5	0.690
K3	2.039	1.544	0.695	0.390	0.137	−0.056	4.858	0.560	39.0	0.760
L1	2.192	1.633	0.789	0.361	0.215	−0.071	5.845	0.457	40.7	0.741
L2	2.122	1.591	0.685	0.347	0.190	−0.107	5.374	0.506	39.7	0.740
L3	2.125	1.581	0.654	0.437	0.116	−0.064	5.315	0.669	39.8	0.739
M1	2.151	1.506	0.664	0.340	0.174	−0.008	4.882	0.512	37.8	0.692
M2	2.172	1.502	0.651	0.346	0.182	−0.058	4.900	0.531	37.6	0.686
M3	2.158	1.468	0.574	0.360	0.125	−0.040	4.652	0.627	36.8	0.677
N1	2.154	1.510	0.592	0.335	0.195	−0.049	4.912	0.567	37.6	0.686
N2	2.182	1.556	0.619	0.275	0.196	−0.134	5.287	0.445	39.0	0.702
N3	2.125	1.464	0.527	0.312	0.161	−0.093	4.559	0.591	36.7	0.683
O1	2.134	1.511	0.662	0.410	0.148	−0.003	4.871	0.619	38.0	0.701
O2	2.203	1.480	0.631	0.365	0.169	+0.034	4.826	0.578	36.8	0.659
O3	2.189	1.459	0.612	0.387	0.139	−0.001	4.663	0.632	36.9	0.668
P1	(2.51) *	(1.41)	(0.53)	(0.36)	0.238	+0.015	(4.99)	(0.68)	34.8	0.545
P2	2.062	1.450	0.648	0.290	0.216	−0.073	4.339	0.447	36.1	0.691
P3	1.969	1.392	0.564	0.342	0.146	−0.037	3.815	0.607	35.0	0.701
Q1	2.128	1.520	0.605	0.338	0.177	−0.084	4.916	0.558	38.2	0.712
Q2	2.145	1.557	0.669	0.331	0.210	−0.068	5.199	0.495	38.8	0.716
Q3	2.260	1.505	0.595	0.301	0.201	−0.053	5.123	0.506	37.6	0.655
R1	2.463	1.510	0.605	0.386	0.159	+0.043	5.621	0.637	37.6	0.600
R2	2.272	1.527	0.605	0.346	0.166	−0.020	5.301	0.572	38.2	0.663
S1	2.212	1.496	0.582	0.309	0.192	−0.043	4.952	0.532	37.3	0.671
S2	2.089	1.468	0.578	0.316	0.151	−0.087	4.504	0.547	37.0	0.696
T1	2.156	1.575	0.706	0.380	0.164	−0.018	5.352	0.538	39.4	0.720
T2	2.044	1.532	0.620	0.386	0.110	−0.067	4.795	0.623	38.6	0.743
U1	2.111	1.579	0.660	0.431	0.152	−0.047	5.266	0.653	39.5	0.738
U2	2.060	1.527	0.624	0.408	0.147	−0.047	4.807	0.653	38.2	0.730

* Figures in () are only approximate and not to be relied upon. This was because of the accident mentioned.
Clutch F, broken in transit, is not included.

RESULTS

It is not necessary to go through all the intricate computations that were made. We can simplify matters by reporting the outcome of most of them very briefly. There were available 16* clutches of three eggs each, and four clutches of two eggs each. On the basis of these clutches, we find:

1. The most striking thing is that eggs fall into two categories, "normal" eggs and "terminal" eggs. The first and second eggs of a clutch of three are not safely distinguishable from one another by any of our statistical "characteristics," but the third egg can be picked out from the others. When a clutch consists of only two eggs, one egg is "normal" and the other terminal. This confirms the impressions of Mr. Schriver and our own suspicions at Pea Island.

2. The length (l) of the egg does not differ significantly either between the eggs of a clutch or between the eggs of different parents. It is therefore of no statistical use for our present questions. On the other hand, the maximum width (B) is very significantly different between the third egg of a clutch and the others. It is less for the third egg, and given that three eggs come from a single clutch, the third may be picked out with almost mathematical precision by choosing the one with lowest maximum diameter.

3. The curvature of the small end of an egg is without significance, but the curvature of the blunt end is highly significant, the third egg of a clutch having a low value of R_B . The ratio R_p/R_B , somewhat surprisingly, is almost without significance.

4. The ellipticity ($2b/l$), like l itself, is of no significance in attempting to sort out clutches from one another, or in sorting out the sequence of a clutch. Also, we find no use for the cubage lB^2 , since the significant element is B itself.

5. The constant, c_2 , does not differ significantly within a clutch, and between different clutches it differs hardly consistently enough to be useful in practice. The other constant, c_1 , on the other hand, differs very significantly within clutches, though between different clutches it is not so significant in this respect as B . It is, therefore, likely to prove most useful in separating out terminal eggs from a large batch of assorted eggs.

It follows that, of the various statistics, only three are useful, or "significant," for our purposes, B , R_B and c_1 . These, however, are not all useful for the same purposes, and the precise question that is asked will determine which characteristic should be analyzed.

If we are given three eggs of a clutch and are told to pick out the third egg, we use B .

If we are given 60 eggs and told to pick out the 20 "last" eggs, we use c_1 .

If we are given six eggs and are told that they comprise two clutches, and are told to separate them into those two clutches, our best plan would be to operate with B .

* There were 16 for profile work, but only 15 for end curvature determinations (because of an accident).

It seems that R_B tends to parallel c_1 , but it is, theoretically, only partially dependent on c_1 , and is partly independent. Its field of utility is perhaps a little less than that of c_1 , but it must be remembered that it is more easily measured, if a spherometer of the right kind is on hand.

In Table II are listed our findings as to the "significance," and hence the utility, of the various characteristics. The percentage of the variance assignable to the three categories (ordinal number in the clutch, different parentage, and "error") is also given. The method of computation is as follows.

The total variance of each characteristic is first partitioned into that due to sequence in a clutch, that due to different parentage, and the "error." Estimates of each of these, isolated from the other two, are computed. If there were m clutches of n eggs each, the mean value of the characteristic for the L th clutch was \bar{x}_L , and the mean for all l th eggs was \bar{x}_p , the mean of the total being \bar{x} , we should have:

$$\text{Variance due to sequence} = m \sum_1^n \frac{(\bar{x}_l - \bar{x})^2}{(n-1)} = V_s$$

$$\text{Variance due to parentage} = n \sum_1^m \frac{(\bar{x}_L - \bar{x})^2}{(m-1)} = V_p$$

$$\text{Variance due to "error"} = \sum_1^{mn} \left\{ \frac{(x - \bar{x})^2 - m \sum_1^n \frac{(\bar{x}_l - \bar{x})^2}{(n-1)} - n \sum_1^m \frac{(\bar{x}_L - \bar{x})^2}{(m-1)}}{(m-1)(n-1)} \right\} = V_e$$

$$\text{The ratios } \frac{V_s}{V_e} = \frac{\text{Sequence variance}}{\text{Error}} \quad \text{and} \quad \frac{V_p}{V_e} = \frac{\text{Parentage variance}}{\text{Error}}$$

are then found. These ratios are measures of the significance of the variances due to sequence and parentage. If there were in reality no variance other than error (i. e., the true value of the computed ratio were zero), the ratio computed from a small sample, although not zero (owing to sampling errors) would generally be small. In fact, in 99% of computations on similar small samples, its value would not exceed a certain limit, called the 1% point, and in 19 such trials out of 20, its value would not exceed a certain (smaller) limit, called the 5% point. G. W. Snedecor's tables* of these 1% and 5% points, or F values, for different sized samples, were used in the present investigation as the criterion of significance of variance. Thus, if the computed ratio exceeded the 1% point, the variance was considered "significant"; if it was less than the 5% point, the variance was "not significant"; while if the value of the ratio was between the 1% and 5% points, the variance was called "barely significant."

The computed ratios, F values, and significances relating to the variances of the different characteristics are tabulated in Table II.

* G. W. Snedecor. Statistical methods, applied to experiments in agriculture and biology. Ed. 4, 1946. Collegiate Press, Inc., Ames, Iowa.

TABLE II

	<i>l</i> (inches)	<i>B</i> (inches)	<i>lB</i> ² (cu. in.)	<i>R_B</i> (inches)	<i>R_P</i> (inches)	<i>R_P/R_B</i>	<i>c</i> ₁	<i>c</i> ₂	<i>2b/l</i>
No. clutches analyzed	15	15	15	15	15	15	16	16	16
Computed variance ratio	{ Sequence: 2.35 Parentage: 0.74 }	{ 21.84 11.83 }	{ 17.60 6.55 }	{ 8.73 2.34 }	{ 0.85 2.77 }	{ 5.25 2.18 }	{ 10.81 2.12 }	{ 2.58 3.19 }	{ 1.09 1.90 }
F value for 1% level	{ Sequence: 5.45 Parentage: 2.80 }	{ 5.45 2.80 }	{ 5.45 2.80 }	{ 5.45 2.80 }	{ 5.45 2.80 }	{ 5.45 2.80 }	{ 5.39 2.70 }	{ 5.39 2.70 }	{ 5.39 2.70 }
F value for 5% level	{ Sequence: 3.34 Parentage: 2.06 }	{ 3.34 2.06 }	{ 3.34 2.06 }	{ 3.34 2.06 }	{ 3.34 2.06 }	{ 3.34 2.06 }	{ 3.32 2.02 }	{ 3.32 2.02 }	{ 3.32 2.02 }
Significance	{ Sequence: no Parentage: no }	{ yes yes }	{ yes yes }	{ yes barely }	{ no barely }	{ barely barely }	{ yes barely }	{ no yes }	{ no no }
Variability	{ Sequence: 0.00118 Parentage: 0.00000 Error: 0.00259 Total: 0.00377 }	{ 0.00246 0.00026 0.00035 0.00307 }	{ 0.1719 0.0115 0.0311 0.2145 }	{ 0.00448 0.00015 0.00174 0.00637 }	{ 0.00000 0.00011 0.00090 0.00101 }	{ 0.00419 0.00023 0.00295 0.00737 }	{ 0.00180 0.00004 0.00055 0.00239 }	{ 0.00044 0.00012 0.00085 0.00141 }	{ 0.00011 0.00020 0.00354 0.00385 }
Partition of variability (%)	{ Sequence: 31.3 Parentage: 0.0 Error: 68.7 }	{ 80.1 8.5 11.4 }	{ 80.1 5.4 14.5 }	{ 70.3 2.4 27.3 }	{ 0.0 10.9 89.1 }	{ 56.9 3.1 40.0 }	{ 75.3 1.7 23.0 }	{ 31.2 8.5 60.3 }	{ 2.9 5.2 91.9 }
Coefficient of variation (%)	{ Sequence: 1.6 Parentage: 0.0 Error: 2.4 }	{ 3.2 1.0 1.2 }	{ 8.0 3.3 3.4 }	{ 10.2 1.9 6.4 }	{ 0.0 2.9 8.6 }	{ 12.1 2.9 10.1 }	{ 23.7 3.5 13.1 }	{ 34.1 17.5 47.1 }	{ 0.8 1.0 4.2 }
Mean value of characteristic for	{ 1st egg: 2.178 2nd egg: 2.148 3rd egg: 2.139 All eggs: 2.155 }	{ 1.553 1.547 1.511 1.537 }	{ 5.26 5.14 4.89 5.10 }	{ 0.674 0.671 0.618 0.654 }	{ 0.354 0.341 0.352 0.349 }	{ 0.526 0.508 0.570 0.534 }	{ 0.192 0.188 0.157 0.179 }	{ —0.0489 —0.0715 —0.0650 —0.0618 }	{ 1.390 1.421 1.406 1.406 }

Next, the relative importance of the different causes of variance is determined by computing the variability, σ^2 , as follows:

Variability due to sequence = $\sigma_s^2 = \frac{V_s - V_e}{n}$

Variability due to parentage = $\sigma_p^2 = \frac{V_p - V_e}{m}$

Variability due to error = $\sigma_e^2 = V_e$

The percentage partition of variability among the three categories is then found, the total being 100%, and by extracting square roots, the coefficient of variability, σ , expressed as a percentage of the mean value of the characteristic may be computed. All these quantities are tabulated in Table II.

Analyses of variance carried out for the various characteristics on the first two eggs of each clutch alone showed *no* significant difference for any characteristic. Results of this are not given in Table II.

It will be obvious that there is no real prospect of identifying the parentage of an egg by any criterion listed. The question whether an egg is a normal egg or a terminal one is all that can be decided. For this purpose, B is the best statistic when a single clutch is offered, and c_1 , when a random collection is offered. This is because c_1 varies but little from bird to bird, but greatly between normal and terminal eggs.

Examination of the mean values of each characteristic for the first, second, and third eggs of a clutch respectively (Table II) shows that for B , c_1 and R_B (the characteristics in which we are primarily interested) the third egg tends to have a value lower than the first two, which barely differ from one another, while c_2 tends to have a higher (negative) value for the second egg than for either of the others, though this does not occur consistently enough to be significant. It is therefore evident that the first two eggs of clutches can not be accurately distinguished from each other, but the third egg may be separated from the others with some considerable accuracy by examining their characteristics.

Accordingly, two experiments were performed on the available sample. First, the experimenter was given the c_1 values of 48 eggs, and the R_B and B values of 45 eggs, and told to identify the 16 "last" eggs of the 48-egg sample, and the 15 "last" eggs of the 45-egg sample. By choosing those eggs with the least c_1 , R_B and B values in each case, and comparing with the known data, the following results were obtained.

Characteristic used	No. of "last" eggs chosen	Fraction correct	Accuracy (%)	Random expectation of accuracy (%)
c_1	11	11/16	68.75	31.25*
R_B	8	8/15	53.3	33.3
B	8	8/15	53.3	33.3

*This value, 31.25%, or 5 out of 16, is the most probable accuracy that would be obtained in one random choice of 16 eggs from the 48. If a larger number of similar random trials were performed, the expectation would of course be 33.3%.

Secondly, the experimenter was given the information used in the first experiment, but was also told which eggs were in the same clutch. By choosing the egg from each clutch with the lowest value of c_1 , R_B , or B , the fractions of "last" eggs selected were as follows:

<i>Characteristic used</i>	<i>No. of "last" eggs chosen</i>	<i>Fraction correct</i>	<i>Accuracy (%)</i>
c_1	12	12/16	75.0
R_B	11	11/15	73.3
B	14	14/15	93.3

The random expectations of accuracy were the same as in the first experiment. Actually, in the last case, 100% accuracy was very nearly obtained, the difference in width of the second and third eggs of the only "wrong" clutch being only 0.001 inch!

Since lB^2 depends for its significance on B , from which it is derived, it serves no useful purpose that B alone can not serve in differentiating between eggs. To make sure that c_1 and R_B are not similarly related, the following formulas may be considered.

$$R_B = \frac{2b^2}{l}(1 + c_1 + c_2)^2$$

$$R_P = \frac{2b^2}{l}(1 - c_1 + c_2)^2$$

$$B = b(2 + c_1^2) \text{ approx., when } 2b = \text{equatorial diameter}$$

The connection between R_B and c_1 is obviously not simple, and their significances for our purpose are not identical.

In an attempt to account, in some measure, for the different variances due to error (Table I), the experimental errors were roughly estimated. This showed that the difference in error found between B and c_1 (coefficients 1.2 and 13.1, Table I) is due largely to experimental error (probable relative errors 0.13% and 3.35%); R_B also has a large relative error (1.54%).

Finally, the four two-egg clutches available were examined, and the two eggs appeared to be most similar to the first and third eggs of three-egg clutches, although the sample was much too small for any significance to be attached to this result. The two eggs differed most in c_1 and c_2 .

SUMMARY

In general, the analysis may be said to show that the terminal egg of a clutch of the Laughing Gull differs significantly from the earlier, "normal," eggs in several particulars. It is probable that this is also true for many other birds, and if so, our results may lead to several useful applications.

Only quantitative characteristics are used in this paper. Other properties,

such as pigmentation of background or of spotting, not here reduced to quantitative measurements, may be as useful or more so.

The *fact* that the terminal egg is different is here proved. The *reason* for its being different is not discussed. This is presumably a matter of the physiological condition of the parent, and this may lead to further understanding of the subject.

Although this paper establishes the fact that, for this particular collection of eggs of this particular species, there is a significant difference between terminal eggs and the other eggs of a clutch, and although the investigation was undertaken in the hope that it might develop results applicable to birds in general, it should be understood that no claim is made that this has been accomplished. It may be that other species, or even the same species under different conditions, do not show the same phenomena. However, qualitative observations suggest that this is probably not the only collection of eggs for which some such results would be valid.

Kendeigh* (1941) found that the *weight* of eggs of the House Wren (*Troglodytes aedon*), near Cleveland, Ohio, varied with the temperature of the days immediately preceding laying, and that there was an optimum temperature (about 20 deg. C.) at which weight was greatest for May and June clutches. The effect of temperature upon the size of eggs of the domestic fowl had been noticed by others (See Kendeigh's bibliography). The possibility that temperature variations may have affected the size and shape of the eggs of the Laughing Gull herein discussed is not disproved in the present paper, but in view of later observations is believed not to be a major factor.

*S. Charles Kendeigh. Length of day and energy requirements for gonad development and egg-laying in birds. *Ecology*, July 1941, v. 22, p. 237-248.

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Art. 6

POPULAR SUMMARY

The Agaristidae are day-flying moths, often strikingly handsome and gaily colored. They seem to favor the tropical parts of the world and many of the species are very rare, some being known only from single specimens. In the course of identifying and arranging the Indo-Australian members of this family in Carnegie Museum's extensive butterfly collection, three new species from the Philippine Islands and a new subspecies from the Aru Islands (near New Guinea) were discovered. These novelties are formally described and christened in this brief technical report.

Additional copies of this paper may be obtained at Carnegie Museum, Pittsburgh 13, Pa., at ten cents per copy.

ART. 6. NEW INDO-AUSTRALIAN AGARISTID MOTHS

BY HARRY K. CLENCH

Arrangement of the Indo-Australian Agaristidae in the Carnegie Museum collection has brought to light several apparently new members of the family, which I now describe.

Scrobigera(?) *claggi*, sp. nov.

Female. Antenna black; frons brownish black; lower hind margin of head with yellowish hairs; palpi black, yellowish laterally except at apex of second, and all of third, segment; patagia, thorax dorsally and tegulae with erect jet black hair; fore coxae with yellow hair; middle coxae similar, more orange; hind coxae black; remainder of legs grayish black, slightly bluish iridescent in some lights. Abdomen black, slightly bluish iridescent above and laterally, less so ventrally.

Both wings above rather shining (but not iridescent) brownish black. Fore wing crossed by a diagonal pale yellowish band about 3–3.5 mm. wide, from middle of costa to, but not quite reaching, anal angle. The band reaches and colors the anterior margin of the costa itself, but at anal angle is separated from outer margin by about 1 mm., and inner margin by less than 0.5 mm. The band is slightly but regularly convex, and of roughly equal width throughout. Hind wing without markings of any kind. Fringe of both wings entirely concolorous with ground color (blackish, or brownish black).

The under surfaces are similar, with the following exceptions. The band of fore wing is rather broader and not of equal width throughout, being about 5 mm. wide on costa, 4.5 mm. in region of lower angle of cell and 5.5 mm. in cubito-anal region. On the fore wing the veins apicad of the band seem to be penciled with slate color.

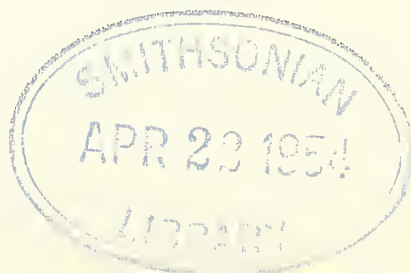
Length of fore wing, 27 mm.; expanse, 55 mm.

Holotype, female, Galog River, 6000 ft., Mt. Apo, Philippine Islands, 7. ix. 1930 (leg. C. F. Clagg). C. M. Acc. No. 9061. C. M. type series no. 182.

Remarks. Apparently closest to *niveifasciata* Rothschild from Borneo, from which it differs in the yellow (rather than pure white) color of the band of the fore wing, and the complete absence of any white in the fringe (abundantly white in *niveifasciata* and other allied species). This is very doubtfully a true *Scrobigera*, but, lacking a male, I hesitate to create a new genus for its reception. It is a pleasure to name this distinct species for Mr. C. F. Clagg, who collected the unique type.

Scrobigera umbrosa, sp. nov.

Male. Antennal shaft black, becoming distally reddish below, at and just before the subapical swelling, and continuing thus almost to apex. Frons laterally yellowish white, mesially black; lower hind margin of head, fore coxae, fore femora, fore tibiae (ventrally), middle tibiae (ventrally) all orange yellow. Palpi with second segment laterally orange yellow, black at apex; third segment black, small. Patagia anteriorly yellowish; mesothorax dorsally,



including tegulae, jet black; ventrally black except as noted above. Legs, except for orange yellow parts mentioned above, grayish black. Abdomen black, dorsally shining metallic greenish blue, iridescent.

Upper surfaces. Fore wing dark black-brown, a few orange scales scattered along the locus of the transverse orange band of the under surface (which band very feebly shows through), and a few metallic blue scales scattered in and just beyond the cell. Fringe concolorous (dark black-brown) except at apex, where it is pure white. Hind wing uniform dark shining metallic greenish blue. Outer margin feebly but definitely sinuate. Fringe long, pure white throughout.

Under surfaces. Fore wing dark brown, blackish in cell. Extreme anterior edge of costa very narrowly orange to beyond middle. Basal third of wing (from $1/4$ out on costa to about $2/3$ out on inner margin) strongly iridescent blue-green. Wing crossed, from just within costa at about its middle straight across nearly to 2A about $3/4$ out along inner margin, by a slender orange band about 2mm. wide, tapering anally, the orange very briefly extending on veins R_1 (distad), stalk of M_{2-3} (distad), Cu_1 (distad) and Cu_2 (anad). Hind wing dark brown, feebly greenish iridescent in basal half. Fringe as for upper surfaces.

Length of fore wing, 22 mm.; expanse, 43.5 mm.

Holotype, male, nr. "Manilla" Philippine Islands, no date (gift of Mrs. Benjamin Brooks). C. M. Acc. No. 4829. C. M. type series no. 183.

Remarks. Very close to *S. semperi* Felder, of which it is just possibly the male. The differences, however, are such that it seems more likely that a different species is involved. The comparisons below are made with a single female of *semperi* (Baguio, 5000 ft., Luzon, Philippine Islands), which should be borne in mind, as some of the observed differences may be merely sexual.

S. umbrosa, then, differs from *semperi* as follows: Antennae ventrally red-dish (uniformly black in *semperi*); anterior of patagia, yellowish (black in *semperi*); lateral yellowish white on frons (uniformly black in *semperi*); absence of transverse yellowish band of fore wing upper surface; yellow costal edge of fore wing (black in *semperi*); the narrower orange band below on fore wing, lacking the inclosed large quadrate black spot so prominent in *semperi*, anally obsolescent (strong, and if anything broader in the anal region in *semperi*).

Argyrolepidia megisto cissia, subsp. nov.

Resembles most closely the form *megisto* Boisduval of the typical (New Guinea) subspecies, from which it differs in the following characters: presence of a narrow white cell-end streak, at either end of which a slender white vein penciling projects basad to fuse with the post-basal transverse white band. Thus a small quadrate black cell spot seems to be formed, outlined slenderly by white. The outermost (post-median) white transverse band of the fore wing is broader than in any form of *megisto*. Hind wing uniform blackish brown above, differentiating it from either of the forms, *intermedia* Jordan

or *basiplaga* Rothschild (both of the typical subspecies). On the under surface the white post-median patch of the fore wing is somewhat rounder than in *megisto*, and on the hind wing a central, white cell-end patch is present, but of variable size. Costad of it is a patch of strong blue iridescence, extending distad along the veins briefly, and on the veins below the cell as well. Costa and entire fringe of hind wing, of both outer and inner margins, is distinctly white. (The costa of *megisto* may be white, but only basally, and its hind wing fringe is white only in the anal half or so of the wing.) The holotype has white marginal shading on the wing in the anal region, which, however, does not occur on the allotype.

The high degree of similarity of the holotype and allotype, differing only in such minor particulars as the size of the central white patch below and the anal white marginal shading below, suggests that, in contradistinction to the New Guinea subspecies, this new one from the Aru Islands may be monomorphic. Such a situation would not be without counterparts in other Agaristidae of the region.

Length of fore wing, 20 mm. (male), 24 mm. (female). Expanse, 41 mm. and 50 mm., respectively.

Holotype, male, and *allotype*, female, Aru Islands (no further data), gift of B. Preston Clark. C. M. Acc. No. 5877. C. M. type series no. 184.

Seudyra jordani, sp. nov.

Male. Antenna slender, regularly tapering distad, not apically or subapically thickened. Frons brownish, paler ventrally, and narrowly whitish along the eyes; crown brownish, laterally pale tan or whitish. Patagia brown, rimmed with pale tan; hair of tegulae long and brown. Thorax above posteriorly jet black or very dark brown-black, anterior to which it is laterally pale tan. Below, fore legs, including coxae, pale tan (grayish dorsally on tibia and tarsus), middle and hind coxae (? poorly visible in the type) and rest of legs bright orange. Abdomen orange, basal two segments dorsally each with a tiny black tuft; terminal segment black above and below, ventrally inclosing a slender transverse orange dash (composed of long hairs), terminally with long pale tan hair dorsally, laterally and ventrally. This gives the black just mentioned the appearance of a subterminal ring.

Upper surfaces. Fore wing orbicular and reniform spots maroon, rather darker than the surrounding ground which is sprinkled with tan scales, and narrowly outlined with pale whitish or tan. Beyond (distad of) reniform pure white in a short, narrow transverse band, not reaching costa and becoming broader and lost in ground color below M_3 . Distad of this the apex is broadly maroon, inclosing along the white just mentioned two very pale lines from costa to Cu_2 in a sigmoid curve (convex costally, concave anally), and inclosing as well two metallic blue spots, a larger subapical and a smaller medio-cubital one. Below cell and Cu_2 maroon, with markings from the base outwards as follows. Scattered metallic blue scales in extreme base; transverse blue band at $1/4$, followed immediately by a slender pale transverse thread-line; a large round blue spot at $1/2$, bounded basally and distally by

maroon, costally by dark maroon; just distad another slender tan thread-line, then a transverse blue band; finally at anal angle an oval red spot bordered narrowly by paler scales, touching the apex at inner margin. Hind wing pure orange with a narrow (2 mm. at M_1) anally tapering dark-brown border. Fringe of fore wing brown touched with white at anal angle; fringe of hind wing uniform very dark brown.

Under surfaces. Fore wing dark chocolate brown with white markings as follows: basal subcostal streak to about $1/3$ out along costa. Costa narrowly whitish to apex, distally a little diffused inward. A basal elongate triangular cell spot and one of hourglass shape just before end of cell. A post-median band from just within costa diagonally to Cu_2 . All these marks, except costal and subcostal, with very sharply defined borders. Hind wing as on upper surface, the dark border perhaps a little less dark. Fringe as for upper surfaces.

Length of fore wing 20.5 mm.; expanse, 44 mm.

Holotype, male, La Lun Mts., 5000 ft., Davao Prov., Mindanao, Philippine Islands, 29-31.xii.1930 (*leg.* C. F. Clagg). C. M. Acc. No. 9163. C. M. type series no. 185.

Remarks. A very distinct and handsome species, the first member of the genus to be recorded from the Philippines. It will stand closest to *S. transiens* Walker with which it agrees in the following significant respects: tapering antenna; dark red spot at anal angle of fore wing above; deep orange color of hind wing, lacking central dark spot either above or below; absence of lateral (stigmatal) dark spots on abdomen. From *transiens*, however, it may readily be distinguished by the following characters*—slightly larger size; very narrow dark border on the hind wing, less than half as wide as in *transiens*, its internal border not irregular as in that species but quite straight; paler tegulae above; black terminal abdominal segment (In *transiens* the apex of the abdomen has black only as a small spot dorsally and a similar one ventrally); the restriction of the dorsal abdominal black tufts to the two basal segments (In *transiens* there is a tuft on each segment to apex), and their reduction in size; the large metallic blue spot on the middle of the inner margin of the fore wing is rather larger than in *transiens*, and the maroon regions of this wing somewhat paler. The fore wing is also more elongate than that of *transiens*.

Named in honor of Dr. Karl Jordan, as a slight tribute from one who has long admired his genius. No matter on what group, or on what problem, he may focus his attention — and it has been focused on many — he brings order out of chaos, and in a few words can say more than the rest of us can in paragraphs. His work on Agaristidae, though only one small facet of his broad interests, is exemplary.

*No examples of the typical (Javanese) subspecies being available to me, I have based all the comparisons here on material from northern India (subsp. *dissimilis* Swinhoe).

ART. 7. OCCURRENCE OF THE EASTERN TIGER SALAMANDER,
AMBYSTOMA TIGRINUM TIGRINUM (GREEN) IN MARYLAND,
WITH NOTES ON ITS LIFE HISTORY

By

CHARLES J. STINE, JR.,* JAMES A. FOWLER†
AND ROBERT S. SIMMONS‡

The eastern tiger salamander, *Ambystoma tigrinum tigrinum* (Green), was first recorded in Maryland by Dr. E. E. Lamkin in February, 1933. This specimen (United States National Museum, 89904) was from Vienna, Dorchester County. A second specimen (United States National Museum, 104405) was collected by Dr. Robert H. McCauley, Jr., in September, 1937 in Denton, Caroline County.

Since these two records, efforts have been made to obtain additional specimens to define more fully the distribution of this salamander in the state of Maryland.

Eggs of this species were obtained by James A. Fowler in a pond at Federalsburg, Caroline County, on March 17, 1946. Eggs were also collected on March 31, 1941, at Hollingsworth Crossroads, Caroline County. In both instances the eggs were hatching.

On a joint field trip on February 22, 1952, the authors found approximately thirty clusters of eggs in a field pond at Golts, Kent County, and a single cluster at Carson's Corner, Queen Annes County. These eggs were also hatching.

With the knowledge that the incubation period for the eggs of this species is about thirty days, it was assumed that the eggs collected in February had been deposited near the middle of January. With this in mind, Stine and Simmons visited a pond two miles east of Massey, Kent County, on the evening of January 15, 1953, following a week of rain, and obtained four male specimens. The air temperature was 49 deg. F. and the water temperature 46 deg. F. The relative humidity was 89%. On five subsequent night trips, a total of eight males and one female was captured.

Of the eight males obtained, the two largest specimens measured 9 and 9½ inches, respectively, in total length. The single female was 8¼ inches

*Curator of Herpetology, Natural History Society of Maryland.

†Director of Education, Philadelphia Academy of Natural Sciences.

‡Natural History Society of Maryland.



long. The vent was slightly longer in the males than in the female, and the cloacal glands bordering the vent in the male were greatly swollen. No significant color differences between the two sexes were noted. The tail fin of each specimen captured was exceptionally wide but, when the specimens were removed from the water, degenerated to its normal width within 24 hours.

Three unsegmented egg masses with unswollen envelopes were also found on the night of January 15, at the Massey pond. Eleven masses were counted in the same pond on January 18. These egg masses were attached to weeds in water 1 to 2½ feet deep, most of them about one foot from the surface.

It is noteworthy that a careful examination of the Golts pond on seven visits from January 15 through February 24, 1953, revealed only three egg masses, a difference of approximately 27 from the previous year. This indicates a marked yearly fluctuation in the number of eggs deposited.

The single female collected was brought back to the laboratory where it deposited 344 eggs, distributed in 12 clusters. Five separate clusters from the Massey pond totaled 296 eggs with extremes of 17 to 92 eggs. It is possible, therefore, that one or two females may be responsible for all of the eggs observed in a given pond. This fact also suggests that the number of salamanders which breed in a single pond is not as great as the abundance of egg masses was previously thought to indicate. Moreover, the importance of the younger females to the survival of the species is obvious.

A visit to the Massey pond on February 24, 1953, revealed only one remaining egg mass, and it was partially hatched. This indicates an incubation period of about thirty-six days in the field when the weather is mild. On the other hand, eggs kept in an aquarium at 65-70 deg. F. hatched in seventeen days.

Field observations have also established that *tigrinum* larvae reach maturity in Maryland about the last week of May, and transform during the last half of June, depending upon the food supply available.

In the area under study, *Ambystoma t. tigrinum* appears to prefer transient field ponds situated close to woods. Although *A. maculatum* occurs in this region, it apparently does not breed in those ponds utilized by *tigrinum*, nor has *tigrinum* been found to breed in ponds preferred by *maculatum*.

The tiger salamander does, however, share its breeding grounds with *A. opacum*. Since this latter species breeds in the fall, its larvae are about half grown when the *tigrinum* eggs hatch. As a consequence, the *opacum* larvae devour some of the smaller *tigrinum* larvae. This situation is soon reversed, however, for within 90 days the surviving *tigrinum* are larger than the *opacum* larvae.

Other amphibians associated with *A. t. tigrinum* in the Massey and Golts ponds were *Triturus v. viridescens*, *Acris crepitans*, *Pseudacris nigrita feriarum*, *Hyla c. crucifer*, *H. v. versicolor*, *Rana catesbeiana*, *R. clamitans*, *R. palustris*, and *R. pipiens*. *Scaphiopus h. holbrookii* and *Rana s. sylvatica* were collected in the immediate vicinity of the ponds in which the *tigrinum* were found.

In summary, *Ambystoma t. tigrinum* is now known from Maryland on the basis of eggs and adults from the following counties, all of which are located in the Eastern Shore division of the Coastal Plain province: Caroline, Dorchester, Kent and Queen Annes. It has also been recorded from Sussex County, Del., in the Coastal Plain. It is probable that this salamander will eventually be recorded from other localities in both the Eastern and Western Shore divisions of the Coastal Plain in Maryland wherever suitable habitats and breeding ponds occur.* The most effective method of establishing additional locality records for this species in the state is to examine likely looking ponds for egg masses or larvae from the middle of January to the middle of June.

The illustrations are from photographs by Stine.

Fig. 1 shows a typical breeding pond of *Ambystoma tigrinum tigrinum*.

Fig. 2 shows an adult male, nine inches in length, from Massey, Kent County, Md.

In Fig. 3 two spermatophores of the male tiger salamander are shown resting on a leaf in the water. The spermatophore on the left is a front view; the one on the right is a lateral view. These opaque masses are about $\frac{3}{4}$ inch in height, slightly exceeding in volume those of the spotted salamander (*Ambystoma maculatum*).

Fig. 4 shows a female tiger salamander depositing her eggs. This captive specimen laid 344 eggs distributed in 12 clusters at varying depths in the water.

Fig. 5 shows the egg mass of the tiger salamander. This mass is highly hygroscopic. The cluster of well advanced eggs has a volume almost five times that of the original mass because of rapid imbibition of water.

Fig. 6 shows eggs of the tiger salamander. At any stage of development it is virtually impossible to lift the mass of eggs out of the water in one piece, and this is an excellent method of identifying the eggs of this species.

Fig. 7 shows eggs of the spotted salamander (*Ambystoma maculatum*). It can be seen that these eggs are more gelatinous than those of *tigrinum*.

*On May 27, 1953, larval specimens of *A. tigrinum* were collected in a pond on the Western Shore near La Plata, Charles County, Md.

Fig. 8 depicts a tiger salamander larva two weeks old. Note the rounded head, and the pointed and transparent tail fin indicating an early stage of larval development.

Fig. 9 shows a mature larva of the tiger salamander. It reveals the broad, dorsally compressed head and the wide tail fin which indicate a high degree of aquatic adaptation. The light lateral (golden) stripe between the two darker stripes is diagnostic of the larva of this species.

The larvae of the marbled salamander (*Ambystoma opacum*) are half grown when the larvae of *tigrinum* are hatchlings, and they frequently devour the smaller larvae of *tigrinum* as illustrated in Fig. 10.

As shown in Fig. 11, the earthworm is a common item on the menu of the tiger salamander.

Fig. 12 shows the tiger salamander (above) and the spotted salamander. Where the two species coexist, one may be mistaken for the other. Note that the spotted salamander (below) has two lateral rows of dots which do not extend onto the sides, while the tiger salamander (above) has many dots forming a diffuse pattern which extends well onto the sides.

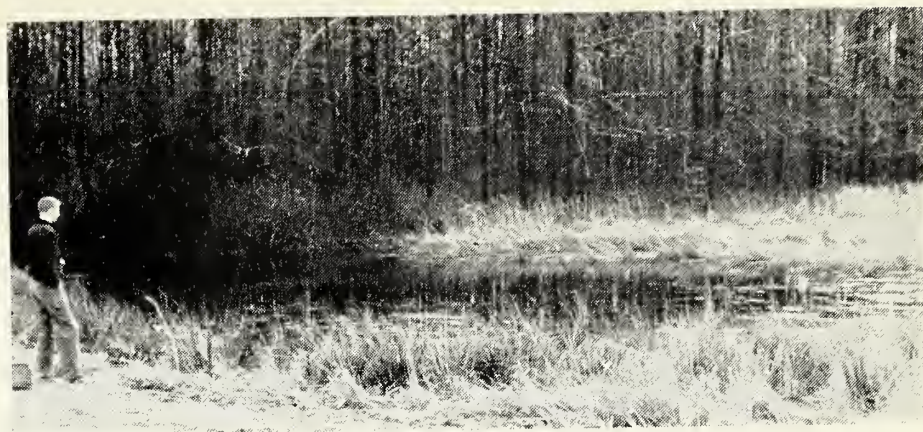


FIG. 1. TYPICAL BREEDING POND OF EASTERN TIGER SALAMANDER.



FIG. 2. ADULT MALE EASTERN TIGER SALAMANDER.



FIG. 3. TWO SPERMATOPHORES OF MALE TIGER SALAMANDER.



FIG. 4. FEMALE TIGER SALAMANDER DEPOSITING EGGS.

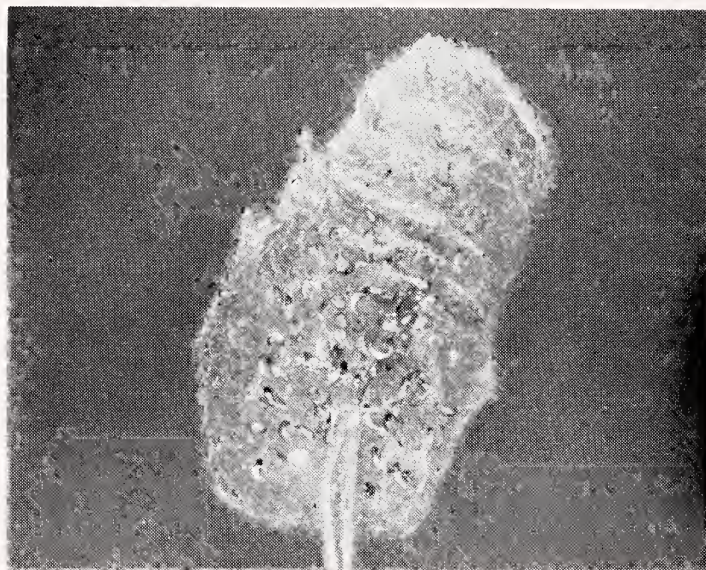


FIG. 5. EGG MASS OF TIGER SALAMANDER.



FIG. 6. EGGS OF TIGER SALAMANDER.



FIG. 7. EGGS OF SPOTTED SALAMANDER.

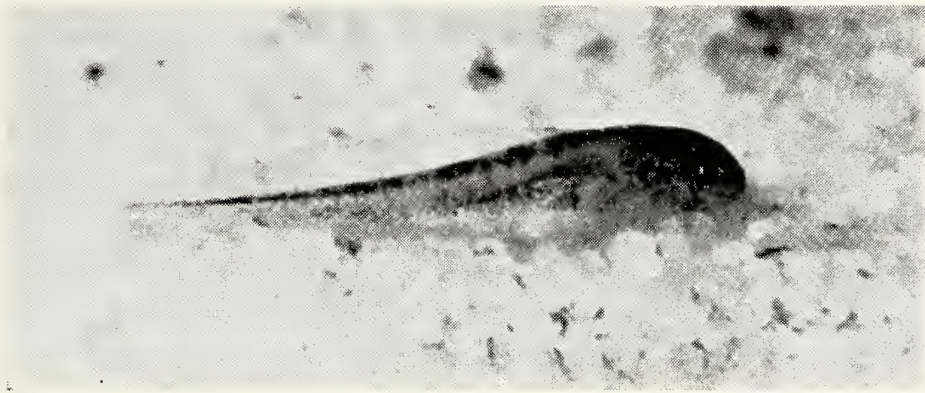


FIG. 8. LARVA OF TIGER SALAMANDER, TWO WEEKS OLD.

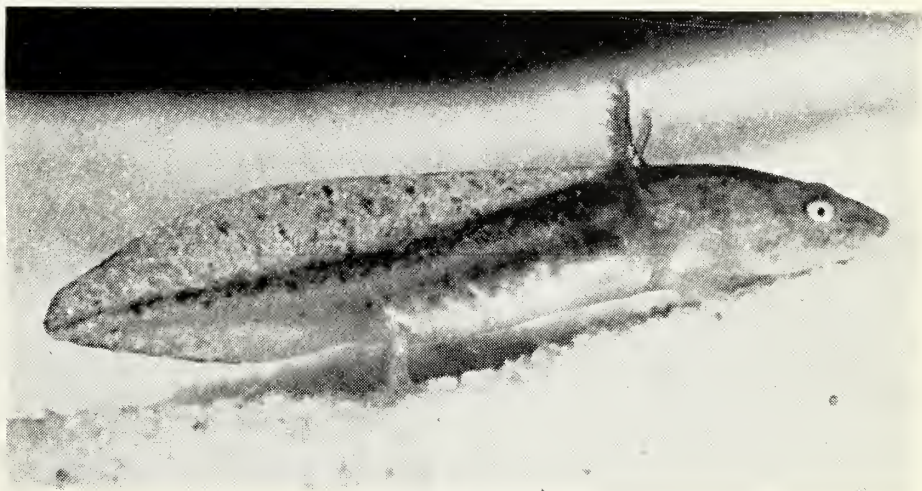


FIG. 9. MATURE LARVA OF TIGER SALAMANDER.



FIG. 10. LARVA OF MARBLED SALAMANDER SWALLOWING
SMALLER LARVA OF TIGER SALAMANDER.



FIG. 11. TIGER SALAMANDER WITH EARTHWORM.

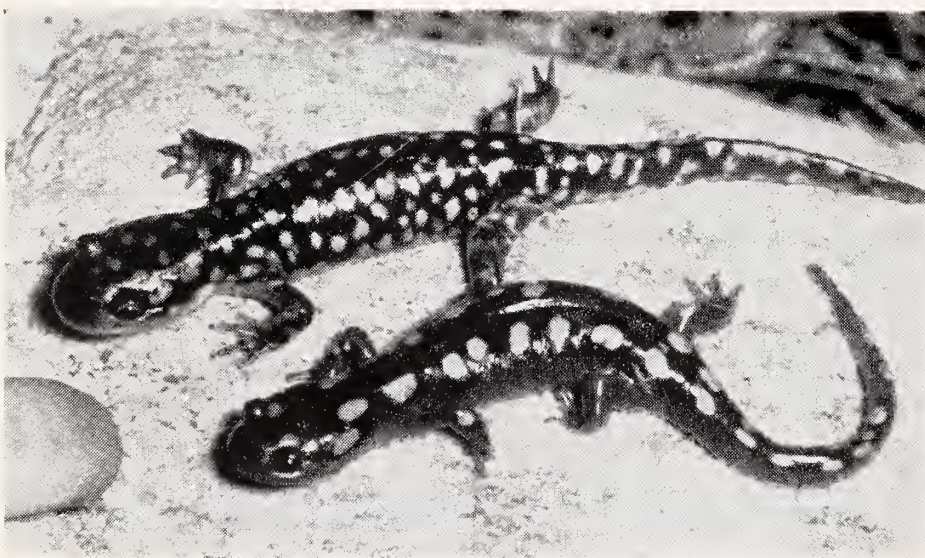


FIG. 12. TIGER SALAMANDER (ABOVE) AND SPOTTED SALAMANDER.

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ART. 8. NOTES ON SOME BIRDS OF THE ADIRONDACK
AND CATSKILL MOUNTAINS, NEW YORK

By
KENNETH C. PARKES

INTRODUCTION

The Adirondack Mountains of northeastern New York and the Catskill Mountains of southeastern New York are of particular interest to students of the North American avifauna. They represent "islands" of a flora and fauna typical of the north woods of Canada, many species finding their southward limit of distribution here. A number of notable ornithologists have studied these areas, but little has been published in recent years. E. H. Eaton's monumental "Birds of New York" gives an excellent account of the ornithology of the state as far as it had been studied up to 1914, and Eaton himself devoted much attention to the Adirondack area. Since 1914, various short papers and notes have appeared, chiefly to announce new breeding records or changes of distribution.

I spent the periods June 12—July 10, 1950, and June 5—July 3, 1953, in the New York mountains. The 1950 trip was made while I was curator of the Louis Agassiz Fuertes Memorial Collection of Birds at Cornell University, and was part of a taxonomic survey of the avifauna of New York. Specimens collected in 1950 are housed in the Cornell collection. The 1953 trip was made under the auspices of Carnegie Museum,* where the 1953 specimens have been deposited.

The present paper is by no means an exhaustive survey of the bird life of the Adirondacks and Catskills, nor is it a complete list of the birds I encountered. Only those species are included for which data were obtained which were thought worthy of presentation in this form. The paper includes a miscellany of notes on distribution, reproduction, molts and plumages, voice, food habits, soft-part colors, parasites and taxonomy.

Many people have contributed in one way or another to the success of the two trips upon which this report is based. Chief among these is Dr. William L. Webb of the New York State College of Forestry at Syracuse University, through whose good offices I was permitted to use the excellent living and laboratory facilities at the Archer and Anna Huntington Wildlife Forest Station, Newcomb, N. Y. Dr. and Mrs. Webb were most helpful and hospitable at all times during my residence at the Huntington Forest, both in 1950 and 1953. Others to whom I am indebted for advice, assistance and information include Harry Ackert, Arthur A. Allen, Greenleaf Chase, Robert W. Dickerman, William C. Dilger, Richard B. Fischer, Winfred N. Ford, Jr., Gordon M. Meade, Charles Schroeder, Robert C. Van Etten and O. William Whiten. The forestry students working at the Huntington Forest were interested and helpful companions. Parasites were identified by Dr. B. V. Travis of Cornell University, Dr. J. C. Bequaert

*This paper is based, in part, upon field work in 1953 which was made possible through the generosity of Dr. and Mrs. Frank W. Preston and Mr. and Mrs. A. H. Schottland, friends of Carnegie Museum in Butler, Pa.



of Harvard College, and Dr. G. P. Holland of the Department of Agriculture of the Dominion of Canada.

PRINCIPAL LOCALITIES MENTIONED

A list of the principal collecting localities follows. Other localities mentioned in the text will be identified by reference to villages or landmarks shown on any standard road map.

Ackerman Pond. An old name for Arbutus Lake, so shown on United States Geological Survey topographic map, Newcomb quadrangle. In Huntington Forest.

Adjidaumo. This is the triangular marsh area shown in the upper left-hand corner of the U.S.G.S. topographic map, Newcomb quadrangle. In 1950 it was mostly marsh, but in 1953 mostly open water. Differences in water level here are due chiefly to damming activities of beaver. Located in Huntington Forest.

Arbutus Lake. A small lake within the Huntington Forest.

Bear Spring Mountain. A ridge lying between the villages of Walton and Downsville, Delaware County, the westernmost extension of the Catskills.

Big Shallow Pond. One of the "Five Ponds," just south of the line between St. Lawrence County and Herkimer County, about seven miles south of the village of Wanakena. It is shown on the U.S.G.S. topographic map, Cranberry Lake quadrangle. The area just east of Big Shallow Pond, shown as a marsh on the topographic map, is a tamarack bog.

Catlin Lake. The largest lake in the Huntington Forest, shown in the lower right-hand corner of the U.S.G.S. topographic map, Long Lake quadrangle.

Chubb River Swamp. A wooded swamp along the Chubb River, shown in the upper right-hand corner of the U.S.G.S. topographic map, Santanoni quadrangle. It lies about two and one-half miles southwest of the village of Lake Placid. For a description of the area, see Pettingill (1951: 376-377). This area, as well as much of the rest of the Adirondack region, was badly hit by the great storm of November, 1950. As a consequence the path mentioned by Pettingill is blocked in many places by fallen trees, and progress through many parts of the forest is exceedingly difficult.

Goodnow Mountain. This is misspelled "Goodenow" on many maps, but is correct on U.S.G.S. topographic map, Newcomb quadrangle. Just south of Rich Lake and within the Huntington Forest.

Huntington Forest. "The Anna and Archer Huntington Wildlife Forest Station, held in trust by Syracuse University for the New York State College of Forestry, is a rectangular 15,000-acre tract . . . in the central part of the Adirondacks west of the village of Newcomb, New York. . . . The area included within the . . . Station is approximately seven miles long in greatest length and three miles wide, lying in a northwest-southeast direction. The main portion lies in Essex County and the remainder, or northwest portion, lies in Hamilton County" (King, Dence and Webb, 1941: 402-403).

The area comprising the Huntington Forest is divided among the Newcomb, Long Lake and Santanoni quadrangles of the U.S.G.S. topographic maps. The major bodies of water lying wholly within the Forest are, in decreasing order of size, Catlin Lake, Rich Lake, Wolf Lake, Arbutus Lake, Deer Lake and Military Lake. The Huntington Forest is being skillfully managed to extract the largest possible amount of information on the wildlife of the central Adirondacks. Research facilities, both field and laboratory, are excellent. For further description of the area, the reader is referred to the following publications: History, policy and program, King, Dence and Webb, 1941; land vertebrates, Johnson, 1937; fishes, Dence, 1937; vascular plants, Heady, 1940. These papers include many maps and photographic illustrations.

Madawaska. A most interesting and readily accessible area about ten miles northwest of Paul Smiths, Franklin County. It is shown at the southern edge of the U.S.G.S. topographic map, Santa Clara quadrangle. I am indebted to Dr. Gordon M. Meade of Trudeau, N. Y., at present our leading authority on Adirondack birds, for an introduction to this area. It is one of the few places in New York where one may be almost certain to encounter the Spruce Grouse (*Canachites canadensis*).

Slide Mountain. The tallest peak in the Catskills (4204 feet), located in Ulster County about seven miles southeast of the village of Oliveria. For a description of Slide Mountain and adjacent area, and a rather incomplete list of the birds of the region, see Daley, 1922. Slide Mountain, with a height from base to summit of about two thousand feet, is almost a textbook illustration of the altitudinal zonation of plants and animals. The foot of the mountain is clothed with typical northern hardwood forest, with birch, beech and maple predominant and a few hemlocks interspersed. As one ascends the excellent state-maintained trail the hemlocks increase until they equal or exceed the hardwoods in number. Balsam fir then begins to appear among the hemlocks, and is the dominant conifer in most of the higher parts of the mountain. At the very summit the mountain is covered with spruce; this is the type locality of *Hylocichla minima bicknelli* (Ridgway), and the southernmost breeding limit of the species.

Rich Lake. The second largest lake within the Huntington Forest. On the shore of this lake the Forest research center is located. State Highway 28N, from Long Lake to Newcomb, passes just south of and parallel to the south shore of the lake.

Whiteface Mountain. One of the tallest Adirondack peaks (4872 feet), and readily accessible by means of a state-operated toll road from the village of Wilmington, Essex County. This road, a magnificent feat of engineering, permits the motorist to drive to within a few hundred feet of the summit, which is reached either by foot trail or by elevator. The higher portions of the mountain are densely covered with stunted spruce trees, the home of Bicknell's Thrush and the Blackpoll Warbler. From about 3000 to 4000 feet the trees are much taller; here live the Olive-backed Thrush, Arctic Three-toed Woodpecker, Brown-capped Chickadee and the two Kinglets.

Wolf Lake. A small lake within the Huntington Forest.

ANNOTATED LIST OF BIRDS

Anas rubripes Brewster. Black Duck

A female with a brood of young about a week old was seen at Adjidaumo on June 17, 1953. These birds were feeding along the shore in close association with the much older brood of Hooded Mergansers mentioned below.

Delacour and Mayr (1945: 21) stated rather abruptly that "it seems obvious that the Mexican and Black Ducks (*diazi* and *rubripes*) are only sub-specifically distinct from the Dusky Duck (*fulvigula*).” They united all of these under *fulvigula*, the oldest name. It is my belief that the case is by no means so "obvious." The Mexican Duck, *Anas diazi*, is so close to the Mallard, *A. platyrhynchos*, that a case might be made for considering it a rather restricted "hen-feathered" subspecies of Mallard, except that *diazi* and *platyrhynchos* are sympatric (Lindsey, 1946: 484). A comparatively recent origin of *diazi* from *platyrhynchos* is suggested by the high frequency of hybridization (Lindsey, 1946: 484).

The Dusky Duck, *A. fulvigula*, resembles the Black Duck more closely than does the Mexican Duck. However, *fulvigula* shows many points of resemblance to *platyrhynchos*; morphologically it is about midway between the (female) Mallard and the Black Duck. Among the points of similarity to the Mallard rather than to the Black Duck are the pattern of individual breast and tail feathers and the seasonal and sexual variations in color of bill. All in all, I prefer to consider the Mallard, Black Duck, Dusky Duck and Mexican Duck as specific entities.

Lophodytes cucullatus (Linnaeus). Hooded Merganser

A juvenal female was collected at the inlet of Rich Lake on July 4, 1950, and a juvenal male at Adjidaumo on June 17, 1953. In spite of the later date, the 1950 bird was somewhat younger, with feathers of the juvenal plumage on the underparts and scapular tracts only. It weighed 227 grams, and was quite fat. The iris was gray, the feet light gray with dark gray webs. The stomach contained dragonfly larvae, fragments of other insects, and sand. The 1953 specimen retained the down on the head, neck and lower back. Wing quills were just appearing. It was one of a brood of nine, and weighed 348.5 grams. In addition to dragonfly larvae, its stomach contained bones of a small frog (*Rana* sp.).

Mergus merganser americanus Cassin. American Merganser

This species was abundant in the Adirondack areas visited in 1950. Almost every small lake appeared to have one or more broods. Rich Lake had at least two. In 1953, on the other hand, not a single bird of this species was observed. A brood on Rich Lake was reported by the student workers at the Huntington Forest, but I was unable to find it. Two small downy young females were collected from a brood of five on Arbutus Lake on July 1, 1950. They weighed 64.7 and 59.3 grams, respectively. The larger bird had two Northern Redbelly Dace (*Chrosomus eos* Cope) in its crop. Its iris was light gray, darkening toward the center; bill black, with

grayish horn tip; legs gray with a yellowish cast, yellowest at sides of toes; webs black.

Buteo platypterus platypterus (Vieillot). Northern Broad-winged Hawk

This appears to be the commonest and most widely distributed hawk in the Adirondacks. Although not usually considered as a predator of game birds, an adult male collected June 15, 1953, had the mandibles of a young Ruffed Grouse in its stomach, together with a number of beetles and a Bog Lemming (*Synaptomys cooperi* Baird). This hawk, collected 1/2 mile south of the south end of Tupper Lake, weighed 372.2 grams and had testes measuring 11 by 6 millimeters.

Canachites canadensis canace (Linnaeus). Canada Spruce Grouse

Recent records of this species in New York are rather sparse. Although it probably occurs in other portions of the Adirondacks, the Spruce Grouse is now reported regularly only in the general vicinity of Paul Smiths, Franklin County. A male weighing 480 grams was collected at Madawaska on June 25, 1953. Of this weight, 8.7 grams represented the crop and its contents—spruce needles and shoots. The stomach contained more of the same, plus a small amount of gravel. This specimen is in heavy molt, the rectrices being shorter than a full-grown upper tail covert. Although this is much earlier than the period given in the literature for the postnuptial molt of the Spruce Grouse, it must be considered to represent that molt; this species is not known to have a prenuptial molt of any extent. The specimen in question is obviously a one-year-old bird, since it retains a number of old brown juvenal feathers, especially about the head. After examination of the considerable series of this species in the Carnegie Museum collection, I have come to the following conclusions:

1. The postjuvenal molt of *Canachites canadensis* is incomplete in that juvenal feathers (other than the two outermost primaries, which have long been used as an aging criterion) are frequently retained, especially about the head, until the first postnuptial molt.
2. Males of this species probably do not breed the first year; testes of the Madawaska specimen measured only 6 by 2 millimeters.
3. The postnuptial molt of yearling males is substantially earlier than that of older birds; late June and early July rather than August and September.
4. In addition to their having retained the two outermost primaries and often other feathers of the juvenal plumage, first-year males may be recognized by the greater amount of white streaking on the throat. This is tentatively suggested by Dwight (1900a: 144). The extent of white on the breast and abdomen does not seem to be correlated with age.

Bonasa umbellus togata (Linnaeus). Canada Ruffed Grouse

This species was common in 1950 and even more so in 1953. During the summer months highway mortality exacts a terrible toll of female and young grouse. The hens and their broods were frequently seen along the road in the early evening, showing little fear of automobiles, often to their undoing. If the parent bird is killed, the young birds (even if perfectly

able to fly) will remain in the immediate vicinity of her body, thus being all too easily killed by the next car to come along.

Specimens collected are as follows:

Bear Spring Mountain, June 18, 1950. Adult female, weight 500.8 grams. Accompanied by quail-sized young. Crop contained wild strawberries (*Fragaria* sp.); stomach the same, plus gravel.

Newcomb (three miles east), June 23, 1950. Two downy young, estimated age at capture one day. Taken alive; mother killed by truck. One died June 26, the other June 30.

Newcomb (entrance road to Huntington Forest), July 4, 1950. Adult female, weight 459 grams. Accompanied by small volant young. Crop contained two wild strawberries and many fruits of *Rubus pubescens* Raf. (locally known as "dewberry"); stomach many *Rubus* seeds plus quartz gravel. This bird was heavily infested with ticks of the species *Haemaphysalis leporis-palustris* (Packard), which has been recorded from Ruffed Grouse on a number of occasions.

Long Lake (three miles east), July 10, 1950. Adult female found dead on highway. Stomach contained seeds of *Rubus pubescens*, leaf fragments and gravel.

Newcomb (along route 28N, south of Rich Lake), June 17, 1953. Adult female, weight 546 grams. Accompanied by half-grown young. Stomach contained seeds, leaf fragments and gravel.

Newcomb (along route 28N, south of Rich Lake), June 19, 1953. Four downy young captured alive; mother killed by car. Age less than one week. Two males, weight 14.0 and 14.3 grams respectively; two females, weight 12.4 and 16.0 grams respectively. Crops contained inchworms (Geometridae) and black flies (Simuliidae).

Newcomb ($\frac{1}{4}$ mile west of Catlin Lake), June 28, 1953. Juvenal male, age about three weeks, weight 82.1 grams. Caught by the head in a snap-back mousetrap (as was another the day before which was too badly chewed by small mammals to preserve). Crop contained one bud of some herbaceous plant and one bug (Pentatomidae). Stomach contained seeds and gravel. This bird was still downy on the head.

Newcomb (Adjidaumo), July 2, 1953. Adult female, weight 467.6 grams. Accompanied by volant young. Crop and stomach contained fruits of *Rubus pubescens*, leaves and (stomach only) gravel.

Newcomb (on route 28N, south of Rich Lake), July 3, 1953. Juvenal female, found dead on highway. This bird was fully feathered and weighed 129.7 grams. Infested with ticks (*Haemaphysalis leporis-palustris*). Crop contained a small green caterpillar. Stomach contained gravel and fruits of *Rubus pubescens*.

Grouse were heard drumming in the vicinity of Slide Mountain on June 5 and 6, 1953. Also the bill and feet of a small grouse were found with a fresh fox dropping on the trail near the summit of Slide Mountain on June 5.

The taxonomy of the Ruffed Grouse of New York is complicated by the fact that intergradation among three subspecies is involved. The present treatment of this species is based on my study of the superb series of several

hundred specimens in the Cornell University collection, supplemented by those in the American Museum of Natural History and Carnegie Museum. The revisions by Todd (1940b), Aldrich and Friedmann (1943) and Snyder and Shortt (1946) were most helpful in this connection.

Typical *umbellus*, as exemplified by birds from eastern Pennsylvania, has a somewhat discontinuous distribution in New York. The grouse of the lower Hudson Valley are apparently pure *umbellus*. The subspecies reappears as the bird of central and northwestern New York. Intergradation with *togata* occurs over wide areas of the state, in which *umbellus*-like, *togata*-like and intermediate birds may be found. These areas include the Hudson Highlands, the Catskills, and a broad zone extending along the western border of the Adirondacks, the Mohawk Valley, and the eastern Finger Lakes. The Ruffed Grouse from Long Island was described by Bailey (1941) as *Bonasa umbellus helmei*. This population was considered by Aldrich and Friedmann (1943: 92) to represent intermediates between *umbellus* and *togata*. While it is true that Long Island specimens do appear to be intermediate between these two subspecies in many characteristics, the extensive series of these birds in the American Museum of Natural History is remarkably uniform. In such a decidedly variable species as the Ruffed Grouse, such uniformity is unexpected in a population supposedly intermediate between two subspecies. Further study may well show that *helmei* is worthy of recognition.

It has long been known that the Ruffed Grouse of the Adirondacks were referable to the subspecies *togata* of eastern Canada (Eaton, 1910: 374). Specimens examined in connection with the present study have confirmed this identification. As mentioned above, there is a broad zone of intergradation between *umbellus* and *togata* in New York. The *togata* influence seems strongest in the Catskills and in the area between the Catskills and the Adirondacks. The specimen from Bear Spring Mountain listed above is a good match for Adirondack *togata*. Two other Catskill birds seen are intermediates (East Jewett and "Sullivan County"). Two out of three Mohawk Valley birds examined are *togata* (Amsterdam and Fort Plain); the other (Fort Plain) is an intermediate. In the Hudson Highlands the grouse are also intermediate, but tending more toward *umbellus*. The *togata* influence is seen in a number of specimens from the eastern part of the Finger Lakes region, but here the problem is complicated by a strong infusion of *monticola* characters.

Mr. Todd, the describer of the subspecies *monticola*, limits its distribution to the southern Appalachians. Aldrich and Friedmann (1943: 93), however, extend the range of this form into western Pennsylvania and southwesternmost New York. After thorough study of the type series of *monticola*, together with more recently collected material from West Virginia and the mountains of western Virginia, I have come to the conclusion that the treatment of Aldrich and Friedmann best reflects the geographic variation observed. True *umbellus* is the palest and most rufescent of the eastern subspecies. Typical *monticola*, like *togata*, is darker and more boldly marked than *umbellus*. However, *monticola* is a brown rather than a gray bird; the brown extreme of *togata* is grayer than the gray extreme of *monticola*.

In the latter subspecies the dorsum is a deeper, less rufescent brown than that of *umbellus*. The background color of the breast and upper abdomen of *monticola* tends to be heavily suffused with deep buff or brown, these areas being pale buff in *umbellus*. Certain specimens from western Pennsylvania approach *umbellus* quite closely, but as a series their affinities with *monticola* are unmistakable.

The subspecies *monticola* appears in New York in its purest form in the mountainous portion of Cattaraugus County. A specimen from Hinsdale in the collection of St. Bonaventure College (kindly loaned by Dr. Stephen W. Eaton) is typical *monticola*. This is not unexpected, as this region in New York is directly continuous, as far as grouse habitat is concerned, with the Pennsylvania range of *monticola*. Aldrich and Friedmann (1943: 92) considered specimens from the Ithaca region to be *umbellus*, "somewhat intermediate toward *monticola*". I found Ithaca and other Tompkins County specimens to represent a highly variable population, but the majority seem to be *umbellus* with a decided *monticola* influence as indicated by the deepened color of the underparts. A few specimens approach true *monticola* quite closely; a somewhat larger number are close to typical *umbellus*. Although not mentioned by Aldrich and Friedmann, certain specimens from this region are intermediate toward *togata*. Intermediates between *umbellus* and *monticola* have also been examined from Wellsville and Binghamton, and such intergradation probably takes place all along the southern tier of counties in New York.

Larus argentatus smithsonianus Coues. Herring Gull

This species breeds on the lakes of the Adirondack region, usually on small islands. Although I saw a number of adult Herring Gulls both summers, I did not observe breeding activity. There is a downy young specimen in the study collection at the Huntington Forest which was banded at Wolf Lake on June 9, 1941, and found dead a week later.

Surnia ulula caparoch (Müller). American Hawk Owl

While collecting at Slide Mountain I was fortunate enough to be the guest of three gentlemen who have purchased and are rebuilding the house described by Mrs. Daley (1922). These men, Charles Schroeder, Bill Whiten and Harry Ackert, while not trained naturalists, are keen observers of the wildlife of the area. Mr. Schroeder told me of an owl which he had kept as a pet early in 1953, and showed me several photographs of it. None of the photographs, unfortunately, was suitable for reproduction, but the subject was unmistakably a Hawk Owl. Mr. Schroeder discovered the bird sitting in an apple-tree in his orchard one morning in mid-January, 1953. Bent (1938: 380) and other authors have commented on the fearlessness of this species, and such was Mr. Schroeder's experience. He was able to capture the owl by hand and make a pet of it. It was not confined, but, of its own volition, stayed in the house or its environs. Fed on raw meat and on mice, it exhibited an unvarying feeding behavior with the latter which may be of interest. It always began by pulling off and eating the mouse's head and then the forelimbs, one at a time. The forequarters were eaten by picking off a piece at a time, but the hindquarters were always swallowed whole, with the tail disappearing last, in typical owl fashion.

The bird lived until mid-April, when it died of what appeared to be a respiratory condition, and was buried. I inspected the corpse to confirm the identification, but its condition after two months' burial precluded its salvage as a scientific specimen.

The Hawk Owl is a rare and infrequent winter visitor to New York, having been recorded upon scarcely more than a dozen occasions. This, to my knowledge, is the first record from the Catskill region. The locality may be cited as West Branch [of the Neversink River], Oliveria, Ulster County, New York.

Sphyrapicus varius varius (Linnaeus). Yellow-bellied Sapsucker

Probably the most common woodpecker in the Adirondack region, and also common in the Catskills. An unsexed bird in full juvenal plumage was collected at the Chubb River Swamp on July 1, 1953. It weighed 45.6 grams, while its male parent, also collected, weighed 43.4 grams. The young sapsucker had not yet commenced its post-juvenal molt. Its iris was dark brown; bill, dark slate gray, lighter along the edges; legs, blue gray; mouth lining, pale flesh.

Dendrocopos villosus villosus (Linnaeus). Eastern Hairy Woodpecker

Eaton (1914: 142) mentioned that some specimens, especially those taken in winter, of Hairy Woodpecker from northern New York approach in size the large northern subspecies *D. v. septentrionalis* (Nuttall) (for which Eaton used the name *leucomelas* Boddaert, considered by recent authors to be a synonym of *villosus*). As indicated by Oberholser (1911: 599) and Ridgway (1914: 203), the Hairy Woodpeckers east of the Rocky Mountains are characterized by a gradual cline in size, decreasing from north to south. Three subspecies are currently recognized: *septentrionalis* (Nuttall), *villosus* (Linnaeus), and *audubonii* (Swainson). The breeding Hairy Woodpeckers of the Adirondacks, while averaging somewhat larger than those from elsewhere in New York, may best be considered to represent the upper extreme of *villosus*. Within New York, this species exhibits a decided seasonal movement, many individuals emerging from the forests during the winter to feed in orchards and parks. There is a noticeable influx of northern birds, recognizable by larger size, during the fall and winter months. Most of these must be considered intermediate between *villosus* and *septentrionalis*, and undoubtedly derive from a geographically intermediate population somewhere in southern Canada. However, some of these winter visitors may be considered true *septentrionalis*. Using the subspecific criteria recommended by Rand (1948b: 176), I identified the following New York specimens in the Cornell collection as *septentrionalis*: Axton, Franklin County, February 22, 1901; Ithaca, Tompkins County, January 11, 1935; Danby, Tompkins County, January 8, 1949.

Dates of the intermediate specimens from New York in the Cornell collection range from October 30 to January 16.

Delacour has recently (1951) advocated the merging of the "Pied Woodpeckers" (*Dendrocopos*) with the Three-toed Woodpeckers (*Picoides*) under the latter generic name. I believe that generic "lumping" is being carried too far in this case. Delacour attempted to draw a parallel between these

woodpeckers and certain of the three- and four-toed shore birds, but among the latter the hallux is non-functional, while in *Dendrocopos* it is functional. Even in *D. pubescens*, in which the hallux is reduced to the minimum in the genus, it is functional and bears a strong claw. There is no sign of a rudimentary hallux in *Picoides*; thus the gap between the three- and four-toed woodpeckers is more abruptly set off than that between the two groups of shore birds. Delacour admitted (p. 50) that *Picoides* "represents an extreme adaptation to arboreal habits" and that, as far as is known, there is a decided difference in food habits between the two groups (*Picoides* gathers almost all of its food by pecking wood; *Dendrocopos* less than half in this manner). It seems to me that this adaptation has led to divergence that ought to be recognized at the generic level. A yellow crown-patch is common to the males of the two Three-toed Woodpeckers. In the large genus *Dendrocopos* (over thirty species) a red patch somewhere on the head is the rule. Delacour made much of the fact that two Indian species of *Dendrocopos* (*mahrattensis* and *auriceps*) have yellow on the crown. I have examined specimens of these two species, and they can hardly be considered an approach to *Picoides*. In *auriceps* the crown is brown and the nape red; in between is a narrow blending zone of yellow. In *mahrattensis* the crown is a pale buff with a sulphur-yellow tinge, very different from the bright lemon-yellow of *Picoides*. In all other respects these two Indian species bear little or no particular resemblance to *Picoides*, and add nothing to Delacour's arguments. I favor retention of the genus *Dendrocopos*.

Picoides arcticus (Swainson). Arctic Three-toed Woodpecker

Eaton (1914: 145) summarized the occurrence of this species as follows. "Throughout the year it is fairly common in all portions of the spruce and balsam belt of the Adirondacks, there ranking next to the Sapsucker and Hairy woodpecker in abundance and probably much more plentiful than the American three-toed woodpecker and the Downy woodpecker." This was certainly not my experience. The only individual of this species seen at close range was an adult female collected July 5, 1950, at about 3800 feet elevation on Whiteface Mountain. This bird weighed 68.3 grams and was growing new feathers in its incubation patch. One was seen at Madawaska on June 24, 1953, and the call note of this (or the following) species was heard at the Chubb River Swamp on July 1, 1953. In spite of Eaton's remarks, I found the Downy Woodpecker (*Dendrocopos pubescens*) to be much more common and widespread in the Adirondacks than the Arctic Three-toed Woodpecker.

Picoides tridactylus bacatus Bangs. American Three-toed Woodpecker

This species is sufficiently uncommon in the Adirondacks to make any definite breeding record worthy of mention. On July 8 and 9, 1950, I collected a juvenal male and its male parent at Big Shallow Pond. The young bird was out of the nest, but was being fed by its parents. The nest was in a dead and barkless tree, about forty feet tall. The top was broken off the tree and the birds apparently entered the nest cavity through this break; I saw no sign of an entrance hole. The nest tree was located along the ecological edge between a virgin spruce forest and a tamarack bog. The young bird weighed 37.1 grams; the adult was not weighed.

Empidonax flaviventris (Baird and Baird). Yellow-bellied Flycatcher

Eaton (1914: 193) quoted reports of this species being a "summer resident" or breeding at Tully Lake, Buffalo, Peterboro, and Granville, Washington County. All of these are old records, and are probably based on misidentification or on summering but non-breeding birds. While it is not impossible that the species may have bred occasionally in some of the cold bogs of the central part of New York, I have seen no such record since those reported by Eaton. At the present time it is known as a breeding bird only in the Adirondacks and higher Catskills. I would have expected it to be confined to the summit on Slide Mountain; however, on June 5, 1953, I found it present well below the limit of spruce and even fir, down to the predominantly hemlock forest. -I also saw or heard this species at Madawaska and the Chubb River Swamp. The description of its voice given by Peterson (1947: 149) is an excellent one. To my ear the note described by Peterson as "killic" bears a close resemblance to the well known "chebec" of the Least Flycatcher (*Empidonax minimus*), but is less harsh and forceful. I have not seen this comparison made elsewhere, but I found the resemblance striking.

Perisoreus canadensis canadensis (Linnaeus). Canada Jay

I encountered what was apparently a family party of this species at Madawaska on June 24, 1953; full-grown young in juvenal plumage were seen. I found the Canada Jays here to be much more shy and difficult to approach than they were (at the same time of year) in Montana. The only bird collected was an adult female in very heavy postnuptial molt; the old feathers are greatly worn and discolored. The rectrices were being replaced centrifugally; the outermost pair had not yet been shed, while the new central rectrices extend 67 and 53 millimeters, respectively, beyond their sheaths. The stomach of this bird contained remains of some large black hymenopterous insect.

The Canada Jay is closely confined to the Adirondacks within New York. Eaton (1914) knew of no records from beyond this region, and the files of the United States Fish and Wildlife Service contain only a record each from Utica and Little Falls, both barely outside the Adirondacks. It was with an understandable surprise, then, that I heard from my friends Charles Schroeder, Bill Whiten and Harry Ackert that they had seen "Canadian Jays" at West Branch, in the valley below Slide Mountain in the Catskills, during the winter of 1952-1953. I questioned them closely and found that they were perfectly familiar with the species, having seen it many times in the Adirondacks; they did not realize that its presence in the Catskills was unusual. It was their habit to place ham fat and suet where it would be available for the winter birds. Blue Jays (*Cyanocitta cristata*) were frequent and abundant visitors to this food supply, and I was informed that they were joined by some four to six Canada Jays. The latter birds appeared early in January, 1953, and disappeared during the first warm spell early in March. This is a most unusual record, but I am convinced of its authenticity; the birds were fully and accurately described to me. It is noteworthy that these ordinarily sedentary northern birds appeared during the same winter and at the same place as the Hawk Owl mentioned above.

Parus atricapillus atricapillus Linnaeus. Eastern Black-capped Chickadee

During the course of my study of the taxonomy of the birds of New York, I amassed a small but representative series of Chickadees taken during the breeding season. Unfortunately the color characteristics upon which principal reliance is placed in the study of geographic variation in this species are subject to much change through wear and discoloration. Breeding birds are very poor for color comparisons. Among the breeding Chickadees of New York, only one apparently consistent color difference was evident. Six specimens in juvenal plumage from the eastern Adirondacks (south shore of Rich Lake, 5; Elizabethtown, 1) are darker and sootier on the dorsum, with less buffy suffusion in the gray, than juvenals from elsewhere in New York (Ithaca, 1; Varna, 1; Stephentown, 3; White Plains, 1). Similar differences are not apparent in the two breeding adult Adirondack birds at hand (parents of the five Rich Lake juvenals), but these birds are quite worn. It is evident that more work must be done on the Chickadees of New York with series of birds in unworn plumage, preferably taken in the spring when the birds are on their territories but not yet subjected to the rigors of raising a family. It can then be determined whether a consistent difference can be detected between the Chickadees of the Adirondacks and those of the remainder of the state.

Although many individual Chickadees, perhaps the majority, are rather sedentary, there is definite evidence for some migration in this species, both from field observation and from banding. Two specimens taken at Inlet, Hamilton County, on November 23, 1940, may have entered the Adirondacks from north of our borders. These two birds exhibit a tendency toward the reduction in buff of the gray dorsum which is one of the characteristics ascribed by Duvall (1945: 56) to a supposed northern race, *P. a. anamesus* (Todd). This race has not yet been recognized by the A.O.U. Check-list Committee, and was refused recognition by Rand (1948a: 58) in a review of the species. The two moot specimens differ most from other New York birds in the length of their tails, 67 and 68 mm. A series of breeding males from all over New York had tails ranging from 59 to 64 mm. in length. Although the wing measurements of these two birds (65 and 67 mm.) fall within the range of *atricapillus* (or *anamesus*, which is said to be similar in size), their tail measurements are extreme and are well within the range of the long-tailed western race, *septentrionalis*. The latter race, however, is distinguishable by the increased amount of white edging to the wing and tail feathers, and, furthermore, does not extend east of Manitoba. It is difficult to conceive of Chickadees migrating as far as New York from a region such as Minnesota or western Ontario where intergrades toward *septentrionalis* might be expected. It is obvious that the geographic variation in the Chickadees of the northeast is not yet fully understood.

All specimens mentioned in the above discussion are in the collection of Cornell University.

Apropos of this species, I might add that I do not share the current majority opinion as to the limits of the species *Parus atricapillus*. Most modern publications consider the Willow Tits of the Old World (for which *montanus* Baldenstein, 1827, seems to be the oldest name) as conspecific

with *P. atricapillus* of North America. Duvall (1945: 51) rebelled at this treatment and listed the morphological characteristics separating the two groups. In addition, a reading of a description of the voice of the Willow Tit (Witherby *et al.*, 1940: 266) will soon convince an American that the species about which he is reading has nothing to do with the Black-capped Chickadee, which is certainly not known for its "series of sweet warbling notes of striking richness" which are compared to those of the Canary and Nightingale.

Parus hudsonicus littoralis Bryant. Acadian Chickadee

Godfrey (1951a) has recently completed a thorough study of the eastern forms of this species. He has confirmed the identity of the Brown-capped Chickadees of northern New York and New England with *littoralis* of Nova Scotia, with the provision that the former average slightly larger. A number of Adirondack specimens from the Cornell collection were examined by Godfrey in connection with his revision.

Tanner (1952), in a most interesting and instructive paper, showed that in the southern Appalachians a definite altitudinal zonation of the two Chickadees, *Parus carolinensis* and *P. atricapillus*, exists. In his summary (p. 424) he stated "These facts indicate: 1) that there is some form of competition between the two species, that operates during the early nesting season; and 2) that the presence of Black-capped Chickadees prevents the Carolinas from inhabiting the higher parts of these mountains." This segregation is not true of the two species of *Parus* found in the Adirondacks. I found *P. atricapillus* and *P. hudsonicus* to be sympatric at Madawaska and at the Chubb River Swamp, where I could hear the call-notes of both species simultaneously. A study of these two species in an area of sympatry might reveal much of interest with regard to competition or lack thereof, and mechanisms of isolation, especially when compared with Tanner's study of *P. atricapillus* and *P. carolinensis*.

Turdus migratorius migratorius Linnaeus. Eastern Robin

An adult female taken June 14, 1953, on the south shore of Rich Lake had as an ectoparasite a flea of the species *Ceratophyllus diffinus* Jordan. "This is a fairly common species, widely distributed in North America and occurring on a number of species of passerine birds." (Dr. G. P. Holland, in a letter.)

Hylocichla ustulata clarescens Burleigh and Peters. Northeastern Olive-backed Thrush

Study of a long series loaned by the United States National Museum together with the material in the Cornell collection convinced me that Godfrey (1951b) and other authors are correct in synonymizing *almae* Oberholser with *swainsoni* (Tschudi). The breeding form of northeastern United States, including New York, is closest to the more rufescent form *clarescens* which was originally thought to be confined to Newfoundland. This is one of the species in which the importance of studying only breeding birds in taxonomic work is clearly shown, since the more western *swainsoni*, a grayer form, occurs as a fairly common migrant in New York. Incidentally, the

color description in the original description of *clarescens* (Burleigh and Peters, 1948) is highly misleading.

On Whiteface Mountain in the Adirondacks the Olive-backed Thrush and Bicknell's Thrush overlap altitudinally during the breeding season. On Slide Mountain in the Catskills, on the other hand, there appeared to be a gap between their respective breeding areas. The Bicknell's Thrushes were confined to the spruce zone at the very summit, while the Olive-backed Thrushes ranged from the valley up to the zone where fir appeared among the hemlocks. The two species probably approach one another more closely than my observations seemed to indicate, but I seriously doubt whether actual overlap takes place on Slide Mountain.

In my experience, the Olive-backed Thrush is the commonest and most widespread of the members of the genus *Hylocichla* in the Adirondacks. It is the only member of the genus which appears to be sympatric with each of the other four species. It may be found side-by-side with Bicknell's Thrush on Whiteface and doubtless other high peaks of the Adirondacks, and I have heard it singing with the Wood Thrush (*H. mustelina*), Hermit Thrush (*H. guttata*) and Veery (*H. fuscescens*) within a few hundred yards of the Research Center building at the Huntington Forest in mixed woods at an elevation of about 1600 feet. On July 6, 1950, Robert C. Van Etten showed me a nest of the Olive-backed Thrush at the southeast corner of Wolf Lake. The nest was near the top of a fir sapling about six feet tall. The four young were frightened from the nest by our approach, but would undoubtedly have left the nest within a day. One of the young birds, a female, was collected.

I have long been of the belief recently expressed by Ripley (1952) that the "wood thrushes" of the genus *Hylocichla* might well be considered congeneric with the neotropical genus *Catharus*. However, the relationships of these birds are currently being investigated by William C. Dilger of Cornell University, and I continue to use the name *Hylocichla* pending the outcome of Mr. Dilger's studies.

Hylocichla minima bicknelli Ridgway. Bicknell's Thrush

Published information on this species in the Adirondacks is exceedingly scanty; so much so that in Wallace's summary (1939: 259) of the breeding distribution of *bicknelli* he stated "Probably the Adirondacks above 3000 feet." Wallace was able to examine personally only a single Adirondack specimen, a juvenal from Keene. I found Bicknell's Thrush to be common on the higher slopes of Whiteface Mountain, its preferred habitat being dense tangles of stunted spruce. Eaton (1914: 523) found it fairly common in the region of Mount Marcy in a similar habitat. On Slide Mountain in the Catskills, type locality of the subspecies, I found Bicknell's Thrush to be fairly common, but closely confined to the smaller spruce at the summit. On Whiteface Mountain, on the other hand, this species extends down into forests of densely packed, towering spruce and balsam fir, where it overlaps the habitat of the Olive-backed Thrush.

I collected three topotypes of Bicknell's Thrush on Slide Mountain on June 5 and 6, 1953. One of the most conspicuous features of the color of the freshly killed birds was the bright yellow of the basal half of the lower

mandible. I have been unable to find this color correctly described in the literature. In a survey of colored plates of North American birds I made while at Cornell (Parkes, 1947), I was able to find only one illustration of *Hylocichla minima* specifically intended to portray *H. m. bicknelli*; this was painted by the late Allan Brooks, and is on plate 92 of Forbush (1929). This plate, which portrays both subspecies, shows the mouth lining of *bicknelli* to be yellow, which is correct. In fresh specimens this yellow continued onto the outer surface of the basal half of the lower mandible; Brooks shows this area as a sort of dull lilac, paler than the equivalent area in the adjacent figure of *minima*. Forbush gave the color of the bill of *H. m. minima* as "dusky, basal half of under mandible yellowish." This is a reasonably good description of the bill of *bicknelli* as I saw it, although I would have said an unqualified "yellow" rather than "yellowish." Forbush did not mention any difference in color of bill between the two races. However, Ridgway (1907: 59) stated that the bill of the larger race, *minima*, was "flesh-colored or lilac in life" at the base of the lower mandible. This contradicts Forbush's description of *minima* but matches Brooks's plate of *bicknelli*. This confusion can be untangled only by careful taking of notes at the time of collection, since these colors are notoriously fugitive. Attention should be paid to this matter of bill color in all parts of the breeding range of *Hylocichla minima*; it is possible that some interesting patterns of geographic variation might thus be demonstrated.

Of the three specimens collected on Slide Mountain, two—a male collected June 5, 1953 and a female collected June 6—still have a few scattered juvenal feathers on the dorsum; such retention of portions of the juvenal body plumage is not mentioned by Dwight (1900b: 310). Neither of the males was at all fat, but the female still retained a substantial amount of fat. This might be interpreted as evidence that the males reach the breeding ground before the females.

Regulus satrapa satrapa Lichtenstein. Eastern Golden-crowned Kinglet

Hellmayr (1934: 510) and other authors have regarded the Golden-crowned Kinglet as conspecific with the Goldcrest (*Regulus regulus*) of the Old World. In 1945, van Rossem, who was in active disagreement with this concept, suggested to those authors who insisted upon merging *satrapa* with *something* (italics his) that they try *R. ignicapillus*, the Firecrest, also of the Old World. Meinertzhagen (1928: 503) did just that, and included the races of the Golden-crowned Kinglet in *ignicapillus* without explanatory comment. I have examined in the American Museum of Natural History all of the known subspecies of *satrapa*, *regulus* and *ignicapillus*. These three groups are certainly closely related. The American forms are roughly intermediate between the two Old World species, although to my eye somewhat closer to *ignicapillus*. The latter species and *regulus* are sympatric in part of their range. It seems best to continue to let the three forms rank as species.

The Golden-crowned Kinglet is a common and widespread breeding species of the evergreen forests of the Adirondacks. A male in full juvenal plumage collected $\frac{3}{4}$ mile south of the south end of Tupper Lake on June 17, 1953, had a dark brownish-gray iris; bill pinkish-horn with blackish-

horn tip; mouth lining bright reddish orange; tarsi horn; toes yellowish horn above, yellow below. An unsexed juvenal from the same brood weighed 6.3 grams, while an adult male collected at Madawaska on June 25 weighed 5.5 grams.

Regulus calendula calendula (Linnaeus). Eastern Ruby-crowned Kinglet

In the literature, there is no definite nesting record of this species in New York. Eaton (1914: 511) cited a record of "what was supposed to be a nest of this species containing young." Examination of the original reference (Ingersoll, 1876: 77; page erroneously cited by Eaton as 116) adds to, rather than reduces, the vagueness of this record. Ingersoll stated "It is supposed to breed in Northern New Jersey, in Western New York . . ." etc. Also, "In Western New York a nest which contained young was reported to have been built in the fork of a tree." Neither Kinglet breeds at the present time in western New York, nor is it probable that the Ruby-crowned nested there in the Nineteenth Century. Perhaps the accounts of the two kinglets were at least partially confused in Ingersoll's article, since he credited the Ruby-crowned with "probably sending a spur southward along the Alleghany Mountains," while of the Golden-crowned he wrote "Its range is nearly as extensive, but more northerly. . . . Nothing is known with certainty of its breeding anywhere in the United States, although it may be found to do so in the northern mountainous portions." Actually the reverse would be closer to the correct status of the two species.

There is a single unpublished definite nesting record of this species in New York, which I include here through the generosity of Dr. Arthur A. Allen. Dr. Allen photographed in color a nest with young found by his son David near Bay Pond, about ten miles west of Paul Smiths and five miles south of Madawaska, in June, 1942. In addition to this definite record, there are several midsummer reports of birds which were almost certainly breeding. Eaton (1914: 511) saw what he believed to be a Ruby-crowned Kinglet carrying food as if to young birds on July 19, 1905, on Mount Marcy. Kittredge (1925) reported one in full song at about 3900 feet on Whiteface Mountain on June 16, 1922. Meade (1950: 24) found three singing birds on July 6, 1950, at Madawaska, and has since told me of finding the species at Madawaska on other occasions in the breeding season. I collected a singing male with enlarged testes and worn plumage at about 3800 feet on Whiteface Mountain on July 5, 1950. A Ruby-crowned Kinglet in full song was seen and heard at the Chubb River Swamp on July 1, 1953, but I was unable to collect it. In summary, it seems evident that the Ruby-crowned Kinglet is a local and uncommon breeding species at several localities in the Adirondacks, even though only one nest has actually been found, to date.

Vermivora peregrina (Wilson). Tennessee Warbler

This is a rare and local breeding species in the Adirondacks. The only definite record I have found in the literature is that of Saunders (1929: 396), who found an adult feeding young near North Elba, and located several singing males during the breeding season in that region. Carleton (1951: 87) saw a singing male July 10, 1930, on Mt. Hurricane, Essex County.

The possibility of occasional breeding of this species in the Canadian Zone of the Catskills is suggested by the observations of Mrs. Daley (1922: 184) at the foot of Slide Mountain. She reported a Tennessee Warbler in full song on June 15, 1919, and stated that this bird was seen "several times through the following weeks". I heard a single Tennessee Warbler singing just below the summit of Slide Mountain on June 5, 1953. This may possibly have been a late migrant. In any case, the inclusion of Slide Mountain as part of the known breeding range of this species (Bent, 1953: 87) is not yet justified.

Parula americana (Linnaeus). Parula Warbler

This species is a well known and common breeding bird of New York, and I have nothing to contribute to our knowledge of its life history or distribution. I include it in order to present the following taxonomic discussion.

The subspecific division of the Parula Warbler is of long standing. The northern race was first separated by Brewster (1896) as *Compsothlypis americana usneae*. Brewster later concluded that Wilson's name *pusilla* was available (although he had rejected it in 1896 on grounds of preoccupation), and went on record (1918) as favoring the combination *C. a. pusilla* for the northern bird. In his original description of "*usneae*" Brewster admitted the instability of some of the characters assigned to the two supposed subspecies.

Ridgway's actions with regard to this species are difficult to reconcile. Writing of certain New York, Pennsylvania and Massachusetts specimens which he had identified as the southern *americana*, he stated (1902: 482, footnote) "A considerable number of specimens from these northern localities I am quite unable to distinguish from southern examples; in fact, if taken in Georgia or South Carolina, they would be considered very typical, some of them extreme, examples of this subspecies, as restricted." This would certainly appear suggestive of the inadvisability of naming geographic subdivisions of this species. Yet a few pages later, Ridgway named a *third* subspecies, *C. a. ramalinae*, from the Mississippi Valley. This was stated to be similar in coloration to *C. a. usneae* (= *P. a. pusilla*), but smaller even than *americana*. Examination of Ridgway's measurements merely confirms the inadvisability of any subspecific splitting at all. Since "*ramalinae*" is said to be similar in color to *pusilla*, the supposed northern type of coloration is thus recorded south to Louisiana and Texas. As to the supposed smaller size, Ridgway's measurements for *americana* and "*ramalinae*" indicate almost identical extremes, with the means of "*ramalinae*" differing from those of *americana* to the following extent: wing, 1 mm. less; tail, 1.6 mm. less; exposed culmen, 0.7 mm. less; tarsus, 0.2 mm. less. The only modern authors who have seen fit to accord recognition to "*ramalinae*" have been Oberholser (1938: 527) and Burleigh (1944: 442).

A large total number of specimens has been examined in connection with the present study, representing the combined series of the American Museum of Natural History, United States National Museum, Cornell University, and Carnegie Museum. It was found that the only characteristic which could be considered at all justified for basing a subspecific division was size.

As indicated by the accompanying table, overlap is extensive. While these two populations might be considered subspecifically separable by some of the more liberal standards which have been applied in such cases, variation and overlap are such that I prefer to follow a more rigid statistical convention such as that proposed by Amadon (1949) and decline to grant nomenclatorial recognition to these populations of *Parula americana*. As to color, identification of specimens without consulting the locality on the label would be virtually hopeless. Ridgway (1902: 484) attributed to the northern race deeper blue upper parts and more intensely black lores. This was definitely not true of the birds examined; in fact, a topotypical series of *americana* from South Carolina was deeper in color than many of the northern birds seen. Although males from the southeastern part of the range of the species seldom exhibit the extreme dark pectoral band of the northern and Mississippi Valley birds, many northern birds also lack this coloration and are indistinguishable from examples of true "*americana*". Certain trends in color and size are admittedly visible within the species *Parula americana*, but identification of individual specimens is so impractical that it is apparent that differentiation in this species has not reached the point at which trinomial nomenclature is justified.

Chord of wing of adult male *Parula americana*

Length in millimeters

	56	57	58	59	60	61	62	63	64
" <i>americana</i> "									
(number of specimens)	1	7	12	14	9	2	2		
" <i>pusilla</i> "									
(number of specimens)		1	1	2	5	8	7	7	1

Dendroica coronata coronata (Linnaeus). Eastern Myrtle Warbler

Bent (1953: 254), in listing the southern breeding limits of this species, mentioned "northern New York (Falls Pond and Buffalo)". As indicated by Eaton (1914: 406), "Its breeding at Utica and Buffalo which has been reported has never been confirmed by later observation." In view of the uncertainty of so many of these early reports, it seems best to reject them in the light of our present knowledge of the breeding distribution of the species involved. As far as the Adirondacks are concerned, Eaton's remark that the Myrtle Warbler is "apparently confined to the spruce belt" is not true at the present time. I found the species common in other conifers as well. I collected a full-grown juvenal in a hemlock woods at the southeast corner of Rich Lake on June 27, 1950, and observed several mated pairs during 1953 in a white pine plantation on the south shore of Rich Lake. In general, the Myrtle Warbler is one of the commonest breeding warblers of the Adirondacks and higher Catskills. I found it so common on Slide Mountain that it is difficult for me to understand the experience of Mrs. Daley (1922), whose only record for the region was one in September in Frost Valley.

Dendroica striata (Forster). Blackpoll Warbler

Bent (1953: 405), giving the range of this species, stated that it breeds south to northern New York "(Mount Marcy and Leyden, rarely Slide Moun-

tain in the Catskills)". On June 5 and 6, 1953, this species was without question the most abundant warbler at the summit of Slide Mountain, and was heard singing down the slopes to the limit of predominantly hemlock forest. On June 5 a female was taken with her completed nest. No eggs had been laid as yet. The nest was about fifteen feet up in a spruce about three inches in diameter, thus being placed somewhat higher than any of the nests described by Bent (1953: 393-394).

The Blackpoll Warbler was also found to be abundant on Whiteface Mountain, but was rarely found at lower elevations in the Adirondacks. Like Bicknell's Thrush it appears to prefer the stunted spruce forests of the higher mountains.

Burleigh and Peters (1948: 119) have attempted to divide the Blackpoll Warbler into an eastern and a western subspecies, naming the latter *D. s. lurida*. Examination of breeding specimens in the American Museum of Natural History and Carnegie Museum indicated that the American Ornithologists' Union Committee on Classification and Nomenclature is amply justified in its refusal to grant recognition to this supposed western subspecies. None of the color differences claimed by Burleigh and Peters could be found in comparing breeding birds from the putative ranges of the two forms; in at least one case, the width of the dorsal streaks, the trend in females was actually the reverse of that claimed by the authors, namely, averaging broader rather than narrower in the western birds. The proposed subspecies *lurida* I consider untenable and I use the binomial for the Blackpoll Warbler.

Geothlypis trichas trichas (Linnaeus). Maryland Yellowthroat

This species was given particular attention while I was collecting for my taxonomic survey of New York birds. The results are based on study of a fine series of breeding birds from the following counties of the state: Cayuga, Delaware, Essex, Oneida, Ontario, Oswego, Rensselaer, St. Lawrence, Tompkins and Westchester. Migrants were available from several of these counties as well as from Saratoga and Yates counties. Comparative material from other states was ample. The most interesting finding has been that there seems to be no reason for the continued separation of *brachidactyla* and *trichas* under modern subspecific criteria, much less for the subdivision of *brachidactyla* into six named races as proposed by Oberholser (1948). Individual variation within a given geographic area is fully as great as observed geographic trends in variation. Measurements presented by Ridgway (1902: 662, 664) obviously show too much overlap to permit use of size as a criterion of separation. As an example, Ridgway's measurements (in millimeters) of the wings of adult males are as follows: *trichas*, 49 to 56.5 (52.9); *brachidactyla*, 51.5 to 59 (55.1). Of 23 New York breeding males measured, only four, or 17.4%, could be identified as *brachidactyla* by the criterion of having a wing longer than 56.5 mm.! Since I found at least one New York bird which slightly exceeded Ridgway's maximum for *brachidactyla*, it is probable that specimens could be found from within the restricted breeding range of *trichas* which would exceed 56.5 mm. in wing length, thus increasing the percentage of unidentifiable specimens.

Color, too, is unreliable. The range of variation in color of specimens taken in New York encompasses the extremes attributed to *brachidactyla* and *trichas*. To offset the possible suggestion that this variation can be explained by the range of *trichas* (*sensu strictu*) actually extending to southern New York, it may be stated that two specimens from southeastern Westchester County which I collected on June 30, 1949, are among the *yellowest* New York birds examined, while specimens with the ventral yellow more restricted, supposedly typical of *trichas*, are scattered throughout the series. The two males with the ventral yellow most restricted were taken on the west shore of Canandaigua Lake (in the western Finger Lakes section) and at 2000 feet elevation on Goodnow Mountain in the Adirondacks. Females with the least yellow were taken at Howland's Island (northern Cayuga County) and at Brasher Falls, near the northernmost border of New York in St. Lawrence County.

Another indication of the great individual color variation in this species is the breadth of the postfrontal white stripe in adult males. Behle (1950: 198) found that this character, sometimes used in subspecific diagnoses, was of little or no taxonomic significance in the western races of *Geothlypis trichas* because of the high rate of individual variation. That this is also true of eastern birds is shown by a series of eight breeding males from the Ithaca region in which the breadth of this stripe varies from two to seven millimeters.

In view of the above findings, and pending a thorough revision of the Yellowthroats of eastern North America comparable to Behle's 1950 paper on the western races, New York birds are here considered to be *Geothlypis trichas trichas*, with *brachidactyla* as a synonym. It might be noted at this point that Todd (1940a: 551) could detect no differences between the Yellowthroats of northern and southern Pennsylvania, although these were supposedly *brachidactyla* and *trichas* respectively.

Euphagus carolinus carolinus (Müller). Western Rusty Blackbird

The trinomial is employed here because of the recently described *E. c. nigrans* Burleigh and Peters (1948), which I somewhat reluctantly recognize. These authors assign Newfoundland and the Magdalen Islands as the breeding area for their new race. The Magdalen Islands birds which they examined are in Carnegie Museum. Included are three adult males and two adult females. Their plumage is in such worn condition that color comparisons are almost valueless; however, I can detect no difference between this series and comparable birds from Quebec and Ontario. However, adult males in fresh fall plumage appear to have the brown feather-edgings of the dorsum much darker in *nigrans* than in *carolinus*; specimens in at least this one plumage are identifiable, so the race may be considered recognizable. Study of the series of this species in the American Museum of Natural History confirmed the difficulty or impossibility of detecting the color differences ascribed to breeding adults. Material in this series indicates that the Rusty Blackbirds of Nova Scotia may be assigned to *nigrans*.

Johnson (1937: 596) indicated the possibility of the Rusty Blackbird being a breeding species in the Huntington Forest. No recent observations, either my own or those of the students and staff of the Forest, have confirmed

Johnson's speculations. His two August records are of no significance as evidence for local breeding, since this species is an early nester and an early migrant. Evidence of this early migration is shown by a flock of Rusty Blackbirds at Adjidaumo on July 7, 1950, from which I collected three adult females and two young birds just beginning their postjuvenile molt. These two young birds show certain differences in color from birds of similar age taken at Churchill, Manitoba; the paucity of material available in this plumage precludes the possibility of a thorough investigation at present.

Two of the adult females collected weighed 58.5 and 61 grams, respectively. The muscles of the lighter bird were heavily infested with a parasite identified by Dr. B. V. Travis as *Sarcocystis* sp. Erickson (1940), in his list of known avian hosts of *Sarcocystis*, listed only one member of the family Icteridae, the Shiny Cowbird (*Molothrus bonariensis*) from Uruguay.

The juvenile male weighed 60.9 grams and the juvenile female 61.5 grams. The young birds had gray irides and pale flesh mouth linings.

Passerina cyanea (Linnaeus). Indigo Bunting

Although this species was not known in the Adirondacks in Eaton's day, it has since invaded the region. It was completely unknown in the Huntington Forest and surrounding area prior to 1947, but is now an abundant breeding bird of that region wherever suitable habitat is present. According to Dr. Arthur A. Allen it is now common at Bay Pond, Franklin County, an area substantially more "Canadian" in its faunal affinities than is the Newcomb area.

Hesperiphona vespertina vespertina (Cooper). Eastern Evening Grosbeak

As shown by Baillie (1940), this species has been steadily extending its breeding range eastward for years. This phenomenon is undoubtedly correlated with the astonishing winter abundance of this species in the eastern United States in recent seasons. The first published report of Evening Grosbeaks in the Adirondacks in summer was that of Fleischer (1943), who saw three adults between July 9 and July 20, 1942, in the vicinity of Elk Lake (northwest of Blue Ridge), Essex County. Barick (1946) reported a number of individuals at Cranberry Lake in the early summer of 1945, and suspected from their behavior that one pair was nesting. Young Evening Grosbeaks have been brought by their parents to feeding stations in the village of Saranac Lake annually since 1947 (Schaub, 1951). Not until 1953, however, were nests of this species actually found in the Adirondacks. It may now be placed on the list of breeding birds of New York without qualification. I am indebted to Greenleaf Chase, District Game Manager for the New York State Conservation Department, for permission to incorporate his data in this paper. Mr. Chase writes as follows (letter of August 13, 1953):

"Two nests found, both of which were completed by the 20th of May and possibly a clutch of eggs was then started. Nests were in the tops of mature hard maples in a beech-birch-maple stand, northwest exposure approximately 1800 feet contour on Shinglebay Mt., Town of Harrietstown, Franklin County. An estimated six pair were nesting on this contour in about a half mile belt. Distinct territories were picked out but due to foliage conditions the other nests were not located. A third nest was found in my yard [Ray Brook, just east of Saranac

Lake], westerly exposure, 1600 ft. elevation on a lateral branch of mature red spruce about 8 feet from the top of the tree. This nest was apparently broken up by crows after the clutch was started. I observed construction of this nest on May 22, 24 and the morning of the 26th — believed to be completed that date. Only materials observed were hemlock twigs taken with great selection by the female from nearby trees. She never appeared to go to the ground for any material. Nest building activities were between 5:00 and 7:00 A.M. and 6:30 and 8:00 P.M. [E.D.S.T.]. The first young grosbeak appeared in the yard near the feeding station on June 23rd. The peak of young bird activity still being fed by old birds was between June 23 and the 6th of July. A very few young birds were being fed by adults as late as the first of August, but as of this date there are no old birds at the feeding station during the day but approximately 15 to 20 young birds on their own are there at one time.

A great number of Evening Grosbeaks breeding in this area is apparent to me not only in the quantity of birds at the station but throughout the surrounding region. Breeding populations are reported at several points throughout the Adirondacks this year where no observations were made previously and yet there are no nests to my knowledge reported other than the ones I have mentioned.

The other points of possible breeding activity are Piseco and Indian Lake."

I can add additional probable breeding localities from my own field work in the summer of 1953. Evening Grosbeaks were regularly seen at a number of points along route 28N from the west end of Rich Lake into the village of Newcomb itself. Dr. Webb informs me that as many as eight or ten in a flock were seen early in June, feeding on the sand piles which the state maintains along the highway. I never saw more than two pairs at one time. Evening Grosbeaks were also frequently seen by the Huntington Forest personnel and myself along the dirt road which follows the north shore of Rich Lake at its western end. All of these birds may probably be considered as part of one population; the exact number of pairs represented would be difficult to determine without marking the birds individually or otherwise determining the extent of their individual movements. Still another locality for this species is on route 10, just southeast of its junction with route 421; this place is on the line between St. Lawrence County and Franklin County, about a mile south of the south end of Tupper Lake. I saw a single adult female here on June 17, 1953; like the Newcomb birds it was feeding on a sand pile.

Breeding in the Newcomb area apparently took place somewhat later than that reported by Mr. Chase. Both sexes regularly visited the sand piles together until mid-June, after which time the females were seldom seen, suggesting that they might be incubating. A female collected at the old camp of the federal Civilian Conservation Corps on the south shore of Rich Lake on June 16 weighed 56 grams. She appeared to have completed what Bailey (1952: 125) called "stage I" of the incubation patch cycle. Defeatherization had taken place, but little vascularization and no edema was apparent in the incubation patch. Her oviduct was not enlarged, and the largest ovule was 2.5 mm. in diameter. Stomach contents included small seeds and sand from the sand pile.

Loxia curvirostra minor (Brehm). Eastern Red Crossbill

I agree with Peters (1943: 98-99), who felt that "Griscom's renaming of the Red Crossbill of eastern North America was uncalled for . . . it seems

to me that the very slight mensural differences make it rash to attempt any switch of names on the basis of an unseen and unmeasured type." To Peters's remarks I may add that Griscom himself (1937: 94), in characterizing the small race *sitkensis* (= *minor* of Griscom's usage), stated that "The bill is also more parrotlike in that the tip of the upper mandible is shorter, not so produced beyond the tip of the lower, because more abruptly decurved, and projecting less horizontally." The photographic illustration from which Griscom deduced the supposed need for a switch in names (van Rossem, 1934) shows that the type of *minor* has the more produced shape of bill of eastern North American birds rather than the stumpy bill of *sitkensis*.

Red Crossbills were seen and heard on Whiteface Mountain on June 11, 1953, and at the Chubb River Swamp on July 1, 1953. Although no specimens were collected, I have examined Adirondack specimens taken by other collectors and thus justify use of the trinomial. I also observed this species at the summit of Slide Mountain on June 5 and 6, 1953. In all cases the birds were in small flocks and were very shy.

Junco hyemalis hyemalis (Linnaeus). Northern Slate-colored Junco

Special attention was given to the Junco during all collecting trips made in connection with my study of the taxonomy of New York birds. Breeding specimens were collected in western New York—whence none was available to Miller during the preparation of his monograph (Miller, 1951: 322)—the Catskills, the Adirondacks, and the highlands of Rensselaer County (one bird). Material of *carolinensis* was collected in the mountains of West Virginia. It was soon found that *all* of the breeding Juncos of New York are variously intermediate between *hyemalis* and *carolinensis*. Miller (1941: 325-326) emphasized the fact that the delimitation of these two races "must be arbitrary if it is to be attempted. Intergradations in all characters neither begin nor end at a single point. . . . The cataloguer desires definiteness and simplicity. Unfortunately these qualities do not exist." He assigned the breeding Juncos of southern New York (the Catskills) to *hyemalis*, but reluctantly, stating that "their inclusion in *hyemalis* seriously distorts the conception of that race. The Pennsylvania birds are intermediate, and little more can be said. I can not see that they fall closer to one race than to the other by a sufficient margin, all characters considered, to warrant a rational decision." The populations of western New York are continuous with those of Pennsylvania, and are equally difficult to place. Certain specimens are indistinguishable from West Virginia *carolinensis*, and at least one specimen which I collected in Allegany State Park, New York, on June 26, 1948, is of *maximum* size even for *carolinensis*. The Catskill population, in my belief, is better dismissed as intermediate than forced into a cubbyhole marked "*hyemalis*". Catskill birds, when freshly collected, resembled *carolinensis* in having bluish-white rather than pinkish-white bills. This difference may even be perceived in dried skins, the majority of specimens of true *hyemalis* showing a definite yellow color in the dried bill which is lacking in *carolinensis* and in most of the New York breeding birds.

Miller (1941: 321) combined for purposes of his study the Junco populations of New England and the Adirondacks, considering them as *hyemalis*. My specimens from the Adirondacks confirm what one would suspect on geographic grounds—the only significant discontinuity among New York breeding Juncos occurs between the Adirondack series and those of the rest of the state. Although the Adirondack series is fairly variable, it is closer, as a whole, to *hyemalis* than is any other sample from the state. This is shown by a slight tendency to smaller size, although one of the largest birds measured was collected at Rich Lake outlet on June 30, 1950. This was also a heavy bird, weighing 20.1 grams; other Adirondack males weighed 18.1, 18.1, 18.3 and 18.9 grams. This large individual also had the bluest bill of the series, which, as a whole, tends toward pinkish bills. The Adirondack birds also show more of a tendency for black to appear on the fifth rectrix, a feather which is pure white in the majority of *carolinensis* (and *carolinensis*-like birds from New York).

In summary, then, it can be said that the only breeding Juncos of New York which may be called *Junco hyemalis hyemalis* without unduly distorting the limits of that race are those of the Adirondacks, and even here there is some variation in the direction of *J. h. carolinensis*. The birds of the remainder of the state are variously intermediate between *hyemalis* and *carolinensis*, and can not be named as a population. When compared with typical examples of the two races, most of these Juncos resemble *carolinensis* more closely than *hyemalis*, especially with respect to color of bill and lack of contrast between colors of head and dorsum.

On June 6, 1953, I found a Junco's nest in a mossy bank bordering the Slide Mountain trail near the summit. The five young were no more than a day old.

Melospiza lincolnii lincolnii (Audubon). Eastern Lincoln's Sparrow

This species was found to be not uncommon along the edges of the open sphagnum bogs and swamps at Madawaska. A male and female collected on June 25, 1953, weighed 16.2 and 15.1 grams respectively. Dr. Gordon M. Meade introduced me to the song of this bird; my previous lack of familiarity with it undoubtedly caused me to overlook this shy species. To both Dr. Meade's ear and mine, the song of Lincoln's Sparrow bears a close resemblance to that of the Winter Wren (*Troglodytes troglodytes hiemalis*), an abundant Adirondack species. I have not seen this comparison made in print. Most comparisons which I have read seem far-fetched to me; thus we see the futility of subjective interpretations of bird song.

Linsdale (1928) and other ornithologists of the Pacific coast group (cf. Grinnell and Miller, 1944: 540) have strongly advocated the inclusion of *Melospiza* in *Passerella*. While these two groups are undoubtedly closely related, I prefer to recognize both genera for a number of reasons. In the matter of color pattern, Linsdale (1928: 349) stated that "there is no constant difference in coloration." All of the members of *Melospiza* are conspicuously streaked dorsally, although this streaking is somewhat obscured in the heavily pigmented Alaskan races of *M. melodia*. Of the Fox Sparrows, only the eastern *P. i. iliaca* is streaked dorsally, and the streaking is of a

sort quite different from that typical of *Melospiza*. Shape of bill is very different in the two groups as a whole; enough difference is discernible between even the most slender-billed Fox Sparrow (such as *schistacea*) and a stout-billed Song Sparrow (such as *atlantica*) to make convergence a reasonable explanation for this approach in shape of bill. Linsdale admitted that the difference in toe proportion employed by Ridgway (1901) was an absolute difference, although he minimized its significance (probably justifiably). Juvenals of *Passerella* are very similar to the adults in color and pattern; juvenals of *Melospiza* show a number of differences. Finally, Linsdale made much of the fact that "the extraordinarily great geographic variation exhibited by each of these groups is a characteristic which markedly separates them from any adjacent group of sparrows". I fear I must regard this as a poor argument. In the first place, it is only partly true. While both *Passerella iliaca* and *Melospiza melodia* are, indeed, highly plastic polytypic species, this is definitely not true of the Swamp Sparrow and Lincoln's Sparrow, which are clearly congeneric with the Song Sparrow. Of these two species of *Melospiza* each has three subspecies, which are indeed poorly marked compared with subspecific differences existing among Fox Sparrows and Song Sparrows. A similar scope of variation is found within the "adjacent group of sparrows" currently included in the genus *Zonotrichia*, ranging from the highly polytypic *capensis* to the monotypic *albicollis*. To carry the argument further, a large number of subspecies is comparatively rare among the Parulidae. Among the notable exceptions are *Dendroica petechia* and *Geothlypis trichas*, both of which are highly polytypic. This can hardly be considered as evidence that the Yellow Warbler is more closely related to the polytypic Yellowthroat than it is to the monotypic Chestnut-sided, Magnolia or Cerulean warblers.

Melospiza melodia melodia (Wilson). Eastern Song Sparrow

This is another of the species to which special attention has been devoted in the course of my New York collecting in recent years, for two chief reasons. It is one of the two species for which New York forms an area of intergradation among three subspecies (the other being the Ruffed Grouse, *Bonasa umbellus*; see discussion earlier in this paper), and it is a species of which the variation in eastern North America has never been worked out in a satisfactory manner. For many years all Song Sparrows east of the Rocky Mountains were unhesitatingly called *M. m. melodia*, and the attention of systematists was focused on the many western subspecies. No full-scale investigation of the eastern birds has as yet been published, although a number of ornithologists have looked into the matter. While at Cornell I assembled a series of nearly sixty breeding adult Song Sparrows from all over New York, the majority personally collected. Some comparative material from adjoining states and provinces was already available in the Cornell collection; more was accumulated in recent years by collecting and by exchange. As a result of careful study of this material, I have come to the conclusion that variation in eastern Song Sparrows is exceedingly complex, and is increased rather than simplified by the comparative lack of marked ecological barriers such as exist in the west. Here in the east there are broad areas of intergradation, characterized both by populations

in which the individuals themselves are largely intermediate, and by those in which individuals having the appearance of two subspecies are intermingled in one area.

The three subspecies of Song Sparrow in New York are *M. m. melodia* (Wilson), *M. m. euphonia* Wetmore, and *M. m. atlantica* Todd. Their respective distributions within the state are, roughly, eastern, western and coastal. *M. m. atlantica* does not fall within the scope of the present paper. The breeding series which I assembled shows that most of New York is a great zone of intergradation between *melodia* and *euphonia*. The breeding birds of the Adirondacks are a good match for the rufescent form of New England and the Maritime Provinces, generally held to represent true *melodia*. It is probable that this subspecies inhabits the St. Lawrence region east of the Thousand Islands, all of the Adirondacks, and the Hudson Valley east to the New England border and south to Putnam County. The Catskills, on the other hand, represent part of the zone of intergradation. A series of 13 specimens (Bear Spring Mountain, Neversink, Beaver Kill and Lew Beach), some kindly loaned by Richard B. Fischer, runs the gamut from "good" *melodia* to "good" *euphonia*. As a series it must be considered intermediate, although specimens from either end would not be out of place in a uniform, typical series of the subspecies in question.

SUMMARY

Collecting trips to the Adirondack and Catskill Mountains of New York were made from June 12 to July 10, 1950 and from June 5 to July 3, 1953. Thirty-one species of birds collected or observed during these trips are discussed in the present paper. These discussions comprise a variety of data on distribution, reproduction, molts and plumages, voice, food habits, soft-part colors, parasites and taxonomy. First definite nesting records for New York of the Ruby-crowned Kinglet (*Regulus calendula calendula*) and Evening Grosbeak (*Hesperiphona vespertina vespertina*) are included, as are the first Catskill records of the Hawk Owl (*Surnia ulula caparoch*) and Canada Jay (*Perisoreus canadensis canadensis*). The proposed mergers of *Dendrocopos* and *Picoides* and of *Melospiza* and *Passerella* are rejected. Subspecies found unworthy of nomenclatorial recognition include *Parula americana pusilla*, *Dendroica striata lurida*, and *Geothlypis trichas brachidactyla*.

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ART. 9. *HYPSOPARIA BOZEMANENSIS*; A NEW GENUS AND
SPECIES OF LEPTARCTINE MUSTELID FROM THE LATE
MIOCENE MADISON VALLEY FORMATION OF MONTANA

BY JOHN A. DORR, JR.
University of Michigan

This paper is intended to inform students of mammalian paleontology about the nature of a hitherto undescribed leptarctine mustelid. It will add to the available knowledge of that poorly known subfamily of carnivores.

Order CARNIVORA
Family Mustelidae
Subfamily Leptarctinae
Hypsoparia gen. nov.

Genotype. *Hypsoparia bozemanensis* sp. nov.

Diagnosis. Skull size and general proportions, except for zygomatic arch, about that of *Leptarctus primus* Leidy (1856). Skull broad across zygomae. Muzzle short, deep, and wide. Two separate, prominent, broad and heavy temporal crests. Dental formula $I\ 3\frac{2}{3}$, $C\ 1/1$, $P\ 3/3$, $M\ 1\frac{2}{2}$. P_4 with well developed posterior accessory cuspule external to midline; quadrangular in outline with well developed hypocone; paracone and metacone separated by a distinct notch. M^1 quadrate, longest on labial side of crown; protocone more anteriorly placed and hypoconal crescent stronger than in *Craterogale* Gazin (1936); differs from *Mephitis* White (1941) in being smaller, less inflated, and longer than wide. Orbit small, subcircular, nearly closed behind. Zygomatic arch extremely large, more so than in *Leptarctus* Leidy (1956) as revised by Matthew (1924); height just posterior to orbit equal to or slightly greater than orbital height, becoming higher posteriorly; greatest height just anterior to glenoid cavity about one and three-quarters times orbital height; ventral edge grooved for reception of masseter muscle. Lower jaw large and heavily built, as in *Leptarctus wortmani* Matthew (1924); anterior edge of coronoid rising steeply, masseteric fossa deep. M_2 reduced.

Generic name, derived from the Greek *hypsos* (high or height) and *pareia* (cheek) refers to the character of the zygomatic arch.

Hypsoparia bozemanensis sp. nov.

Holotype. Carnegie Museum 9574. Anterior portion of skull including left zygomatic arch back to glenoid cavity with dentition lacking only upper incisors. Associated lower jaws with dentition complete on both rami except for incisors, of which only left I_3 and alveoli remain; right ramus lacking coronoid, condyle and angle. Collected in 1939 by J. LeRoy Kay and A. Lewis of a Carnegie Museum field party. The specimen has suffered a certain amount of crushing, but probably not enough to distort the proportions of its important features very much.

Horizon and type locality. Uppermost Miocene, Madison Valley formation. From a channel-fill of gray volcanic ash exposed in road cut along south side of road between Bozeman and Anceney, Montana, 13 miles west of



Bozeman on divide between Gallatin and Jefferson rivers, center of N $\frac{1}{2}$, Sec. 13, T.2S., R.3E., Gallatin County, Montana.

Diagnosis. So far the only known species of the genus. Generic and specific characters at present inseparable. Trivial name from town of Bozeman, Montana, near type locality.

Description of holotype and comparisons. Knowledge of the skull and jaws of leptarctine mustelids has heretofore been based for the most part upon the excellent skull and jaws of *Leptarctus primus* described and designated as neotypes, by Matthew (1924, p. 138-146). So far, specimens referred to other genera and species have been rather fragmentary. In most cases, therefore, the holotype of *H. bozemanensis* can best be compared with the neotypes of *L. primus*.

The skull of *H. bozemanensis* is very close to that of *L. primus* in size. It is short, compact, heavily built, and broad across the zygomae. The muzzle is short, deep and wide. There are two temporal crests. These crests arise from the posterior edges of the postorbital processes of the frontals, are about two and a half millimeters high, and trend inward, posteriorly, toward the midline of the skull at an angle of about forty-five degrees. The median faces of these crests slope toward the midline of the skull, whereas in *L. primus* they overhang slightly. The full backward extent of the temporal crests can not be determined from the specimen, which is incomplete posteriorly. The orbit is subcircular, equal in maximum height and length, and nearly closed posteriorly by the postorbital processes of the frontal and jugal the tips of which are only three millimeters apart. There is no prominent lachrymal process such as is described in *Craterogale*, but only a small, low swelling.

The small, round, infraorbital foramen lies above the anterior edge of P^4 .

The most distinctive feature of the skull is the relatively great height of the zygomatic arch. The maximum zygoma height is 1.72 times the maximum orbital height in the holotype of *H. bozemanensis*, and nearly twice the maximum zygoma height of *L. primus*. Maximum height is reached just anterior to the glenoid cavity where the zygoma flares pronouncedly downward and somewhat less so upward. In *L. primus* the maximum is near the center of the arch. The lateral face of the zygoma is convex (with a minor lower hollow possibly due to crushing) and the inner face is concave in *H. bozemanensis*. The reverse is true in *L. primus*. The ventral edge of the zygoma is grooved for reception of the masseter muscle in *H. bozemanensis*.

The dental formula was I $3\frac{2}{3}$, C $1\frac{1}{1}$, P $3\frac{3}{3}$, M $1\frac{2}{2}$. The upper incisors and the anterior ends of the premaxillae are missing in the specimen. The skull posterior to M^1 is broken away. M^2 was probably absent as in *L. primus*. Alveoli for three lower incisors on each side are present in the lower jaw. The maximum length of the upper row of teeth is close to that of *L. primus*, but the individual teeth are larger and hence more closely crowded. A short diastema separates the canine from P^2 and P^2 from P^3 . The teeth of the premolar-molar series become progressively larger posteriorly. P^3 is more inflated than P^2 and is round, whereas in *L. primus* P^3 is triangular; both P^1 and P^3 are unicuspidate, with complete cingula.

P^4 is quadrangular, with four distinct cusps and an antero-external stylar cuspule. The posteroexternal corner is more protracted posteroexternally than in *L. primus*. The external shearing blade is more deeply notched, hence the paracones and metacones are more widely separated. The external groove between the paracones and metacones is deeper than in *L. primus* and extends downward to include the cingulum, causing a more pronounced inflection of the outer margin of the tooth. P^4 is longer than wide, the reverse of the condition in *Leptarctus progressus* Simpson (1930). Also in distinction, P^4 in *L. progressus* is triangular in outline and lacks an indentation of its anterior margin. This tooth is slightly smaller, but otherwise similar, to P^4 in *Mephitis mephitis*.

M^1 is quadrangular and has four main cusps. A smaller cusp adjoins the posterolabial corner of the hypocone, and there is a small mesostylar cusp in contrast to the condition in *L. primus*. The parastylar corner forms a more distinct anteroexternal projection than in *L. primus*. The tooth is longer than wide; whereas, in *Mephitis mephitis*, M^1 is described (White, 1941, p. 92) as being more inflated and wider than long. The anterior margin curves inward in *H. bozemanensis*; is straight or slightly rounded in *L. primus*. M^1 in *L. oregonensis*, in distinction, is described (Stock, 1930) as having a strong external cingulum and mesostylar cusp, a slight enamel elevation posterior to the protocone, and a posterointernal crescent with two major cusps (hypocone and metaconule?) and a third minor cusp. In contrast to *Craterogale simus* Gazin (1936), M^1 in *H. bozemanensis* is longer labially than lingually, with a stronger hypoconal crescent, and a more anteriorly placed protocone.

The upper and lower canines are stouter in *H. bozemanensis* than in *L. primus*. A flat anterior facet is worn on the right upper canine from the tip nearly to the base of the crown.

The lower jaws in *H. bozemanensis* are larger and more heavily proportioned than in *L. primus*, and are close to *L. wortmani* in those respects. The two mental foramina are located below P_2 and P_3 . The masseteric fossa is larger and deeper than in *L. primus* or *L. wortmani*, and has sharper anterior and inferior lips, and extends farther downward toward the lower edge of the jaw.

The anterior edge of the coronoid rises steeply backward. The anterior edge of the mandibular symphysis rises steeply forward at an angle of about forty degrees to the long axis of the horizontal ramus. The incisors were closely appressed. A slight diastema separated P_2 from the canine; a lesser one separated P_2 from P_3 . The remaining teeth are closely crowded. P_2 - P_3 are trenchant and unicuspidate. P_3 is smaller and less inflated than in *L. wortmani* and lacks the distinct posterior accessory cuspule external to the main cusp. It is smaller, less inflated, and with weaker internal cingulum and anterior and posterior cingular shelves than in *L. wortmani*. The tooth is broadest posteriorly, and the posterior edge is flat.

M_1 has three large but low cusps on the trigonid, and a broadly basined talonid bearing two main cusps and a smaller, median hypoconulid. It is similar to M_1 in *Leptarctus*. M_2 is reduced, longer than wide, and has an

elevated posterior heel bearing two cusps on an anterointernally directed cross-crest, with a small, low, median hypoconulid.

The dental foramen lies on the inner face of the coronoid, below the level of the condyle, half way between the level of the condyle and angle, and well below M_3 . In *L. wortmani*, the dental foramen is at the level of M_2 .

	<i>Hypsoparia bozemanensis</i> gen. et sp. nov., holotype, C.M. 9574	<i>Leptarctus primus</i> neotypes A.M.N.H. 18241, skull A.M.N.H. 18270, jaws
<i>Measurements in millimeters</i>		
Orbit, maximum diameters		
Length to middle of postorbital process....	13.0	12.0
Height	13.0	14.4
Zygomatic arch		
Maximum height	22.3	11.7
Height just posterior to postorbital process of jugal	14.4	
Muzzle width at P^2	22.2	23.1
Anterior alveolar border of C to posterior edge of infraorbital foramen	18.9	16.8
Skull height above M^1 at orbital center	23.2	23.0
Anterior edge of C to center of postorbital process of frontal	35.5	35.5
C- M^1 , alveolar length	31.7	30.5
P^2 , maximum at cingulum	L, 3.7	3.3
	W, 2.3	1.9
P^3 , maximum at cingulum	L, 5.0	4.7
	W, 3.5	2.9
P^4 , maximum, parallel to outer margin	L, 8.4	7.2
maximum perpendicular to outer margin through protocone	W, 6.2	5.2
M^1 , maximum, parallel to outer margin	L, 10.0	8.2
maximum perpendicular to outer mar- gin through protocone	W, 8.2	7.0
Depth of lower jaw		
below P_2	13.6	10.0
below M_1	13.8	10.2
below M_2	15.0	11.2
Length of jaw, anterior edge of I_1 alveolus to back of condyle	65.2	
C- M_2 , inclusive, alveolar length	37.6	33.9
P_2 , maximum at cingulum	L, 3.3	
	W, 1.9	
P_3 , maximum at cingulum	L, 4.6	
	W, 2.8	
P_4 , maximum at cingulum	L, 6.2	5.6
	W, 3.3	2.9

	<i>Hypsoparia bozemanensis</i> gen. et sp. nov., holotype, C.M. 9574	<i>Leptarctus primus</i> neotypes A.M.N.H. 18241, skull A.M.N.H. 18270, jaws
Measurements in millimeters		
M ₁ , maximum at cingulum	L, 10.7 W, 5.0	9.9 4.0
M ₂ , maximum at cingulum	L, 5.4 W, 3.7	

Discussion. *Hypsoparia bozemanensis* is readily distinguishable from previously described species of leptarctine mustelids on the basis of differences in what are accepted, and probably valid, specific characters. It is more difficult to draw valid generic distinctions between the few, mostly fragmentary, specimens that have been referred to the subfamily.

The main distinction between *Hypsoparia* and *Leptarctus* so far seems to lie in the greater relative and absolute height of the zygomatic arch in *Hypsoparia*. The proportions of other structural features, common to the two genera, differ less markedly or not at all. It is possible that the nature of the difference between the zygomae of the two types might be that of variation between sexes in two individuals of the same genus and species. If that were so, however, the degree of sexual dimorphism would be far greater in leptarctines for that particular character than in other extinct and living mustelids. The pronounced furrow on the lower edge of the zygoma, and the large, deep masseteric fossa, suggest an unusually powerful masseter muscle in *Hypsoparia*. The extreme height of the zygomatic arch may also reflect this. If so, it is likely that the massive zygomatic arch is a habitus character that would be found about equally developed in both sexes of a particular genus of leptarctines but reaching an extreme in *Hypsoparia*.

If the distinctions proposed in diagnoses of other leptarctine genera are valid, then *Hypsoparia* is generically distinct. Unfortunately, the zygoma in *Hypsoparia* can be compared only with that in the neotype skull of *L. primus*; the few specimens referred to other genera and species are fragmentary and lack this structure.

The holotype of *H. bozemanensis* was found in the ash channel-fill at the type locality in association with the fossil remains of horses, a beaver, a mylagaulid, and other mammals. The faunule is now being studied and the full results will be published later, but the age of the faunule now appears to be very latest Miocene. This locality lies between ten and fifteen miles east and southeast of the type locality of the Madison Valley beds of Douglass; that is, the bluffs bounding the Madison River Valley on the east. The stratigraphic position of the ash channel-fill, in relation to the beds at the type locality of the Madison Valley formation, could not be conclusively established. The ash may be equivalent to, and probably is no higher than, the uppermost beds at the type locality.

Acknowledgments. I completed the field and laboratory work on this paper while a member of the staff of Carnegie Museum, Pittsburgh, Pa. Dr. J. LeRoy Kay, Curator of Vertebrate Fossils at Carnegie Museum, offered helpful advice and assistance in the laboratory and field, and loaned the

holotype of *H. bozemanensis* to me that I might complete the study. I was graciously permitted to examine pertinent specimens in the paleontological collections of the American Museum of Natural History.

Plate 21 illustrates several aspects of the holotype specimen.

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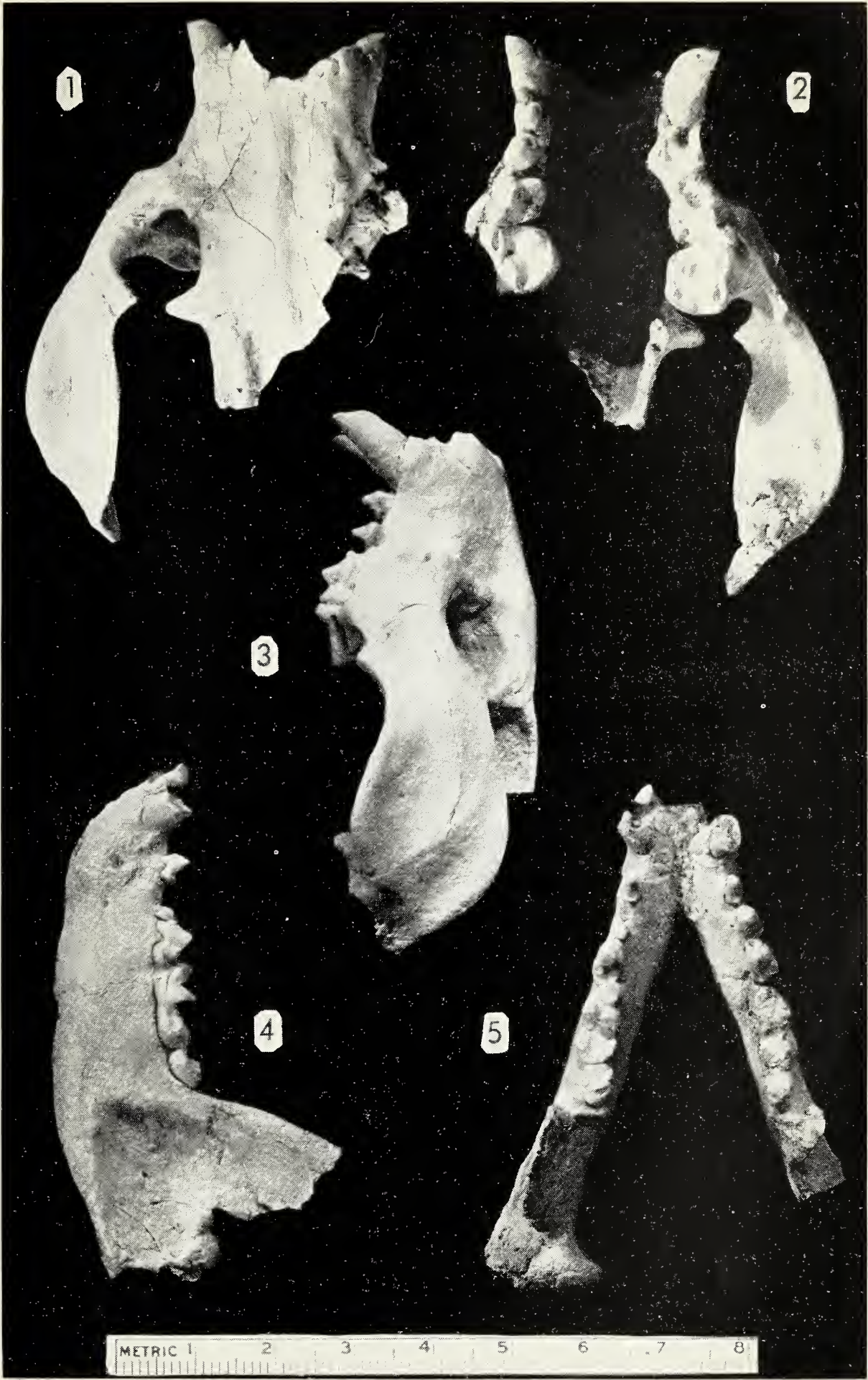
EXPLANATION OF PLATE

Hypsoparia bozemanensis gen. et sp. nov.

Genotype and holotype, Carnegie Museum 9574

All figures about natural size. Centimeters numbered on scale.

- FIG. 1. Skull, dorsal view.
FIG. 2. Skull, palatal view.
FIG. 3. Skull, lateral view.
FIG. 4. Lower jaws, left ramus, lateral view.
FIG. 5. Lower jaws, occlusal view.



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ART. 10. REMARKS ON EVOLUTION OF COLOR PATTERN IN THE
GOSSEI GROUP OF THE FROG GENUS *ELEUTHERODACTYLUS*

BY COLEMAN J. GOIN

University of Florida, and Carnegie Museum

INTRODUCTION

The *gossei* group (formerly called *luteolus* group) of the genus *Eleutherodactylus* in Jamaica is fairly well known both ecologically and systematically and shows a high degree of polymorphism in color patterns. Furthermore, there are data available to show that at least part of this polymorphism has a genetic basis. In view of this, I have been giving some thought to the variability of color pattern in the species of this group in the light of their possible evolutionary history. As there seems to be a correlation among them, I present my interpretation of the evolution with special reference to the color patterns in this group of frogs.

I make no attempt to give in this paper all of the basic data on which my conclusions are founded since to do so would lengthen it unduly and this information is readily available in the papers cited in the text.

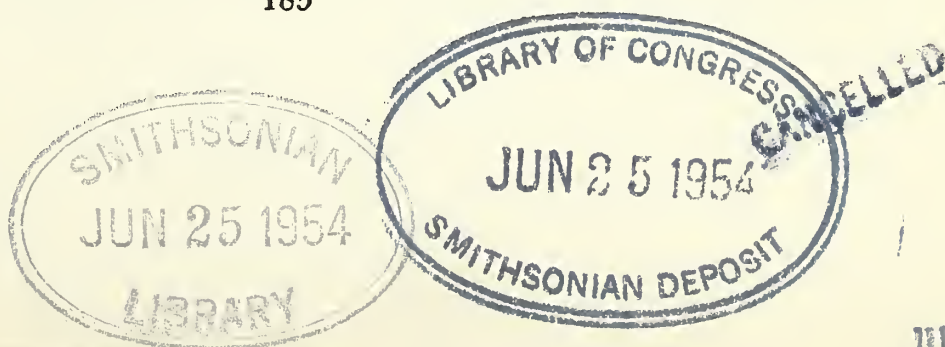
The group of species herein called the *gossei* group may be characterized in general by their terrestrial habits, feebly developed digital disks, smooth back and belly, long vomerine series, and the presence of red in the groin in life. Specimens of *E. alticola* sometimes have fairly short vomerine series (although in other specimens it is quite long) and *E. fuscus* apparently lacks red in the groin in life. The frogs in this group are noisy in life.

This is the predominant group of *Eleutherodactylus* on the Island of Jamaica. In addition, there are several species in the *cundalli* group, which are in the main rather silent, terrestrial species; the aquatic *orcutti*; and the arboreal *jamaicensis*, whose relationships are not well understood. There is, of course, the introduced *martinicensis*. The introduced *planirostris* I would put close to the *cundalli* group.

As Dr. Dunn (1926a: 115) has said, "Jamaica has specialized in the development of the *luteolus* group [= *gossei* group]." Thus, I would conclude that not more than four main stocks of *Eleutherodactylus* (excluding the recently introduced forms) have reached Jamaica, and I believe unquestionably that the differentiation of the species of the *gossei* group has taken place entirely on the Island. How long this stock has been on the Island is, of course, a matter of conjecture, but there seems to be no doubt that we have here seven species evolved from the same basic stem and all closely related.

MATERIAL

I have had the opportunity to study and observe most of the Jamaican species of *Eleutherodactylus* in the field. In my opinion, the *sine qua non* of studying frogs of this genus is observation of the forms in life. Thus, my own field experience in Jamaica has helped me not only in deciding on what should be included in the *gossei* group, but also in concluding that certain other species should not be therein included. I have not seen *E.*



junori or *E. fuscus* in life. I include them in the group with the approbation of Dr. E. R. Dunn and Dr. W. Gardner Lynn, collectors and describers of these respective species, and two of the foremost students of this genus of frogs.

In addition to hundreds of individuals observed in the field but not collected or preserved, and museum specimens of some of the species studied after preservation, I have analyzed the color pattern of the following numbers of specimens in life: *gossei*, 190; *nubicola*, 1302; *alticola*, 417; *pantoni*, 353; *andrewsi*, 17.

TAXONOMY OF THE GROUP

As I interpret it at present, the *gossei* group in Jamaica comprises the following species:

- E. gossei* Dunn
- E. nubicola* Dunn
- E. alticola* Lynn
- E. pantoni* Dunn
- E. fuscus* Lynn and Dent
- E. andrewsi* Lynn
- E. junori* Dunn

These seven obviously closely related forms are, with one possible exception, quite distinct. In the region of Clydesdale, for example, *andrewsi*, *pantoni* and *gossei* occur together. The voices of all three forms are quite different, as are the clutches of eggs. In other parts of the Island, *gossei*, *pantoni* and *junori* are found together. Several of the species show marked altitudinal limitations. Even in these forms, however, there is overlap and, where the ranges do overlap, the species remain quite distinct in voice, structure of the clutch of eggs, etc. There is, in fact, perfectly good evidence that each of the forms is a distinct species with the exception of *andrewsi* and *junori* the ranges of which, as known at the present time, are adjacent but non-contiguous. These two forms may possibly, although I think it unlikely, be shown to be subspecies of a single species.

This group of frogs is the one which has so long been known as the *luteolus* group. I have recently demonstrated (Goin, 1953) that *luteolus* Gosse is in reality quite a different species and, after having collected it and observed it in life, I am convinced it is not a close relative of any of the above species.

DISTRIBUTION

The ranges of these species may be generalized as follows.

E. gossei. Widespread from sea level to about 4500 feet; apparently absent from most of the dry south coast except on the Liguanea Plain about Kingston.

E. nubicola. The parishes of Portland, St. Andrew, and St. Thomas in the Blue Mountains and adjacent portions of the Port Royal Mountains at elevations between 3500 and 6000 feet.

E. alticola. The Blue Mountains from about 5600 feet to the top of Blue Mountain Peak (7360 feet).

E. pantoni. Widespread from the eastern to the western end of the Island from altitudes of about 500 feet to 4000 feet.

E. fuscus. Known at present only from Dolphin Head, Westmoreland, and Quick Step, St. Elizabeth.

E. andrewsi. In the Blue Mountains from about 3000 to 5000 feet.

E. junori. Known only from Spaldings in the Parish of Clarendon, at an elevation of about 2900 feet.

There are thus two wide-ranging species, *gossei* and *pantoni*. Both *andrewsi* and *junori* have their ranges overlaid by, and contained within, the ranges of both *pantoni* and *gossei*. *E. nubicola* seems to replace *pantoni* in the Blue Mountains above elevations of about 4000 feet, while *alticola* in turn replaces *nubicola* from slightly below 6000 feet to the tops of the highest peaks. On the slopes of the mountains, the ranges of *pantoni* and *nubicola* overlap by only a few hundred feet at about the 4000-foot level while the ranges of *nubicola* and *alticola* overlap by a few hundred feet at about the 6000-foot level. *E. fuscus* is known only from two specimens from Dolphin Head and one from Quick Step. With so few specimens it is impossible to generalize regarding its ecology or distribution, but it is known to occur with *pantoni* at Dolphin Head.

HABITS AND HABITAT

The group as a whole is comprised of terrestrial species. In habits and habitat *gossei* is perhaps the most generalized. It is found in rather dry situations and also in some of the humid cloud forest ravines in the mountains. During the day the frogs seem to spend most of their time under rocks; at night they come out and call from the ground, at times climbing up on rocks and even sometimes on low bushes.

E. pantoni seems to be, next to *gossei*, the most tolerant of dry conditions although it is also found in very humid situations. As with *gossei*, the frogs can be found under rocks during the day. In the evening they can be seen and heard calling from the ground and low rocks.

E. nubicola is an inhabitant of the cloud forest in the Blue Mountains below 6000 feet. Specimens can be collected along the trails during the day by looking under rocks; at night the frogs leave their shelters and sit on the ground or low rocks.

E. alticola inhabits the cloud forest in the Blue Mountains above 5600 feet and ranges up to the wind scrub on the top of Blue Mountain Peak where it is very common. Specimens can be collected by looking beneath the rocks that border the trails.

E. andrewsi I have never taken in the daytime. All of the specimens that I have collected were found along the trail. They were calling from the open rocky region on the trail proper as well as from beneath the bushes beside the trail. I have never seen any of them show any propensity for climbing.

E. junori is known from seven specimens which Dr. Dunn collected at Spaldings in September, 1925. I spent six nights collecting in the rocky hills about Spaldings in late August and early September in 1952 but was not able to collect *junori* or to hear its voice. Concerning this species Dr.

Dunn (1927: 535) says: "This is a tiny, short-legged, short-snouted form, which lives in the woods, and calls exclusively from holes in the rocks. The call can hardly be transliterated, sounding like a child's wooden ratchet. It is a long call, very deceptive and hard to trace, rising to a high pitch and falling again to silence, so that I did not know whether it was a night bird flying past, or whether it was on the ground or in the trees, until I saw the frog calling."

E. fuscus is known from two specimens from Dolphin Head, Westmoreland, and one from Quick Step in St. Elizabeth. I have never seen it alive or heard its call.

I have collected the eggs of *gossei*, *nubicola*, *alticola* and *pantoni*. The breeding habits of these species do not seem to give definite clues as to their relationship. If anything, I would say that they are more a reflection of the size. *E. pantoni*, the largest of these species, lays the largest number of eggs, with as many as 104 in a clutch; *nubicola*, the next smaller in size, lays from 26 to 75 eggs in a single clutch; *gossei* has up to 33 eggs in a clutch; the 20 clutches of *alticola* eggs that I have collected averaged 23 per clutch. The eggs of both *nubicola* and *pantoni* are large and in the main non-adhesive so that they spread out in one or two layers in the nest whereas the eggs of the two moderate-sized species, *gossei* and *alticola*, are both smaller in size and much more adhesive so that they tend to cluster up into little groups somewhat like bunches of grapes. The eggs of all four of these species are laid in hollow places under rocks.

EVOLUTION

The detailed descriptions of the morphology of these species can be found in Lynn (1940) and Lynn and Dent (1943), so I list here only the major features of their morphology. As stated above, the species in the group can, in general, be characterized by long vomerine series, feebly developed digital disks, smooth back and belly, and red in the groin in life.

E. gossei. A moderate-sized species practically invariable in the characters listed above.

E. nubicola. A rather large species with the characters of the group plus the additional character of having the belly quite dark in life.

E. alticola. A moderate-sized species with the characters of the group except for the fact that the vomerine series may vary from long to quite short.

E. pantoni. A large species characterized by the yellow color of the belly in life.

E. fuscus. A large species lacking (at least in the three known specimens) red in the groin in life.

E. andrewsi. A small species.

E. junori. A small species.

It can thus be seen that there are three large species, *nubicola*, *pantoni* and *fuscus*, two moderate-sized species, *gossei* and *alticola*, and two small species, *andrewsi* and *junori*.

As Dunn (1926a: 116) has pointed out, "Adult size is one of the most

ART. 11. GEOGRAPHIC DESIGNATION OF THE MEMBERS OF THE CHADRON FORMATION IN SOUTH DAKOTA

BY JOHN CLARK
Princeton University

In 1937, I recognized three members of the Chadron formation of South Dakota* which were locally identifiable by their lithology. At the time, it seemed inadvisable to give these members geographic names, because they were recognizable only locally. The designations A, B and C and 1, 2 and 3 had already been used for purely faunal subdivisions known to be invalid, so I used the names Lower Member, Middle Member, and Upper Member. Work on lower Oligocene sediments in other localities has necessitated occasional references to these members and confusion has arisen as to whether, for instance, the expression "older Chadronian" means "coeval with the Lower Member of Clark 1937" or simply "older part of the early Oligocene." Personally, I do not approve of geographic names for thin, local members of formations, but the overwhelming majority of vertebrate paleontologists favor geographic names in this case. I, therefore, wish, at this time, to designate a standard section for the Chadron formation in South Dakota with geographic names for its members.

The standard section for the Chadron formation in the Big Badlands is the south fork of Indian Creek, Pennington County, from Sec. 34, T.3S., R.12E. to Sec. 10, T.4S., R.12E. The member formerly designated as the Lower Member shall be called the Ahearn member, from the name of a ranch formerly at the mouth of the south fork of Indian Creek. The member formerly known as the Middle Member shall be called the Crazy Johnson member. The member formerly known as the Upper Member shall be called the Peanut Peak member.

These last two names are the alternative local names given to the prominent butte in the southern part of Sec. 10, T.4S., R.12E., which is called both "Crazy Johnson Butte" and "Peanut Peak", referring to attempts by a man named Johnson to raise peanuts on top of it. The standard section for these two members is the north face of this butte, illustrated in Plate XXI, upper figure, of the *Annals of the Carnegie Museum*, v. 25, art. 21, referred to above.

It is obvious that more widely used geographic names would be preferable to these. However, the three members are all fossiliferous and are most characteristically developed at this locality, and no other geographic names are available here. It seems advisable, therefore, to let geologic practicability override euphony and lexicographic elegance in this case.

In the original definition of the three members, the Ahearn (Lower) member was described as characteristically including red sediments. It was assumed that all of these reds were inherited, either from a lateritic soil on the uplands or from the Spearfish and Opeche formations of the Black Hills.

*J. Clark. The stratigraphy and paleontology of the Chadron formation in the Big Badlands of South Dakota. *Annals of the Carnegie Museum*, 1937, v. 25, art. 21, p. 261-350.

Careful restudy has confirmed the presence of inherited reds in clay pebbles and small laminae interbedded with greenish sediments. However, small hematite concretions also occur, with ramifying extensions which could not have undergone transportation. Also, in some cases a red-stained zone of hematite concentration surrounds bone inclosed in even-grained, otherwise green sandstone. It is evident, therefore, that both inherited and epigenetic reds occur within the Ahearn member. The diagenetic nature of the red-orange color in the Peanut Peak and Crazy Johnson members has been further confirmed by recent field studies; it is apparent that three different types of red beds are represented in the Chadron of South Dakota.

In the original paper, bentonitic material was not reported for the western-derived Chadron sediments (p. 284). It was first detected by Ray Alf, now of Webb College, California, who wrote an unpublished paper on the subject. I have since confirmed Mr. Alf's observation. All three members contain ash, which differs from the ash of the overlying Brule in being completely bentonitic, while the Brule ash consists partly of fresh shards.

Additional information and interpretation will be presented in a forthcoming paper on the faunas of the three members.

constant characters in this group." I agree with him that adult size is a valid specific character.

I believe that much of the evolution in the group on the Island of Jamaica has been ecological rather than geographic in nature. With so many of the species overlapping in range, and not showing any marked ecological differences, I puzzled for a long time about how they could have evolved, until I happened to recall a statement by Dunn (1926b: 37) concerning ecological speciation, "where the nearest relative is in the same region and the same habitat but of a quite different size."

I consider *gossei* the most generalized species, and such forms as *andrewsi*, *junori* and *alticola* the more specialized. *E. pantoni* and *nubicola* certainly lie between these two extremes. Not enough is known of *fuscus* to place it precisely, but from its rarity I am inclined to think it is most likely a specialized species.

When adult size is considered, the distribution of the species forms a definite pattern. Thus, on the lower slopes of the Blue Mountains, there are three species occurring together, the large *pantoni*, the moderate-sized *gossei*, and the small *andrewsi*. As we go up the mountain slopes, the large *pantoni* is replaced by the large *nubicola*, and only above the range of the moderate-sized *gossei* does the moderate-sized *alticola* appear. Likewise, in the vicinity of Spaldings there are three species, the large *pantoni*, the moderate-sized *gossei* and the small *junori*. So far as is known, the ranges of the small *junori* of the central mountain mass and the small *andrewsi* of the Blue Mountains do not come in contact. Thus we have in the group two species of approximately the same size occurring together only in the case of *pantoni* and the very rare *fuscus* in the western portion of the Island. Whether or not there is ecological separation between these two species has not been determined.

It thus seems to me that the evolution has been about as follows: A moderate-sized *gossei* or pre-*gossei* parent stock gave rise to a large-sized *pantoni* stock with differences in size permitting them to occupy the same major habitat and both of them becoming widespread.

E. pantoni, in turn, gave rise to the small *junori-andrewsi* stock. It may seem strange for me to consider *pantoni*, the largest species in the group, as a close relative, and probably the parent of, the *andrewsi-junori* stock, the smallest species in the group. For anyone who doubts their close affinity, however, I would suggest that he examine and compare specimens of *andrewsi* with immature specimens of *pantoni* that are equal in size to *andrewsi* and have only the pattern of pelvic spots.

E. andrewsi and *junori* have perhaps speciated geographically from a pre-*andrewsi-junori* stock or, and I consider this more probable, they both may be independent derivatives of *pantoni*.

I believe the same *gossei* or pre-*gossei* stock gave rise to the large *nubicola* in the cloud forest region of the Blue Mountains between 4000 and 6000 feet, with *nubicola*, in turn, giving rise to the moderate-sized *alticola* which occupies the higher peaks of the Blue Mountains above the range of *gossei*.

The little-known *fuscus* is apparently related to *pantoni*.

My concept of the evolution of this group is illustrated diagrammatically in Fig. 1.



FIG. 1. SUGGESTED PHYLOGENY OF THE *gossei* GROUP OF THE FROG GENUS *Eleutherodactylus*.

COLOR PATTERNS OF THE GROUP

While it is impractical to define all of the minor pattern modifications in this group of *Eleutherodactylus*, there seem to be at least eight basic types of patterns, and these are described below. The citation at the end of the description of each pattern is to the figure of this pattern, from an actual specimen, in Lynn's "Amphibians" [of Jamaica] (Lynn, 1940).

Mottled. The mottled pattern consists of a brown background overlaid by a mottling of dark brown or black. The most consistent element of this pattern is the arrangement of dark pigment in a W-shaped mark on the back in the suprascapular region. This W-shaped mark extends from above the arm on one side of the back to above the arm on the opposite side with the apex of the middle portion being directed anteriorly and being located precisely on the midline of the back. Generally the area of the back immediately caudad of the two posteriorly directed apices of the W is somewhat lighter than the surrounding dorsum. Posterior to this lighter area, a fainter wavy line of dark pigment is discernible. In addition, a dark interocular bar is present. It is of interest to note that the W-shaped mark described above is the one so easily recognized in many different species of *Eleutherodactylus*. Most of the variation in the mottled pattern is apparently due to differences in intensity of pigmentation. While there is a great deal of individual variation, there appears to be a general tendency for intensity of pigmentation to increase with age. In hatchlings the pattern as described above is immediately apparent, but in large mature individuals it is quite often obscured by a general darkening of the dorsum. (Plate IV, Fig. 6.)

Dorsolateral stripes. This pattern consists of two broad cream-colored bands, one on each side, originating on the posterior margins of the upper eyelids, passing posteriorly above the tympani directly backward through

the arms of the W and finally terminating on the back above the insertions of the hind limbs. As the cream-colored bands pass through and thus obliterate the arms of the W, all that is left of it is the central portion forming an inverted V-shaped mark in the suprascapular region between the two lateral stripes. (Plate VI, Fig. 11, c.)

Picket. In this pattern there is a light area bounded anteriorly by the posterior margin of the middle section of the W-mark. Behind the two posterior apices of the W the lateral margins of this light area appear comparable to the median margins of the cream-colored areas in individuals which have dorsolateral stripes. Thus when both dorsolateral stripes and picket patterns occur in the same individual, the light picket occupies the entire area between the dorsolateral stripes posterior to the V-mark. (Plate VI, Fig. 11, b.)

Mid-dorsal stripe. This pattern in the adults consists of a narrow cream-colored median line extending from the snout to the vent, there branching and continuing on the posterior margin of each leg to the sole of the foot, terminating at the juncture of the fourth and fifth toes. Ventrally, a median, narrow, cream-colored line extends from the tip of the chin to the crotch. It should be noted that this is the only one of the patterns herein described that carries over onto the ventral side of the body. The midventral portion of this pattern tends to become obliterated with increasing size (hence age) of the individual, but is discernible as a median line on the chin and throat in the largest specimens. In hatchlings the mid-dorsal portion of this line extends only as far forward as the median anteriorly directed apex of the W but in mature individuals it continues on to the snout. (Plate VI, Fig. 11, a.)

Broad mid-dorsal stripe. This pattern consists of a sharply defined, light, cream-colored stripe running from back of the head to the vent along the median dorsal line. Throughout most of its distance it is about as wide as the greatest diameter of the eye. Its margins are sharply defined by black or very dark brown. (Plate IV, Fig. 7, e.)

Pelvic spots. The major feature of this pattern consists of a rather small but conspicuous, coal-black, more or less rounded patch along the back above each groin. (Plate VII, Fig. 13.)

Interocular bar. This consists of a sharply-defined, cream-colored, slightly convex bar across the top of the head from the upper eyelid of one eye to the upper eyelid of the other eye. It is margined both anteriorly and posteriorly by buff brown or black. (Plate VII, Fig. 12.)

Purple. This pattern occurs only with dorsolateral stripes and may be a modification of it. It consists of a moderately narrow mid-dorsal stripe, from tip of snout to groin, Indian purple in color, two dorsolateral stripes of pearl gray extending from the eyes to just behind the groins, each in turn bordered by Indian purple. The background between the median Indian purple stripe and the Indian purple stripe forming the inner margin of the dorsolateral stripe is seal brown. (Plate IV, Fig. f.)

Of the eight color patterns described above, I have recently published data (Goin, 1950) indicating that the following patterns are genetic in nature:

E. nubicola. Dorsolateral stripes, picket, mid-dorsal stripe, mottled.

E. alticola. Dorsolateral stripes, mid-dorsal stripe, mottled.

E. pantoni. Dorsolateral stripes, mottled.

Goin and Cooper (1950: 2) pointed out that individuals both with and without dorsolateral stripes occurred in a single set of hatchlings of *E. gossei*.

As these patterns are known to be inherited in these species, I believe that Sturtevant's (1948: 230) conclusion "there can be no doubt that, in general, related species have essentially the same complements of genes" makes it safe to assume that they are genetic in the entire group.

As I pointed out (Goin, 1950), the genes involved seem to control patterns that overlie and modify the basic mottled pattern. It should also be pointed out here that these patterns are not mutually exclusive so that various combinations of them can, and do, obtain. Thus, a *pantoni* may have dorsolateral stripes, mid-dorsal stripe, and picket at one and the same time. Hence there are many more phenotypic expressions possible than there are basic patterns involved.

The species in the group exhibit these basic patterns as follows:

E. gossei. Mottled, dorsolateral stripes, picket (?), mid-dorsal stripe, broad mid-dorsal stripe, pelvic spots, interocular bar, purple.

E. pantoni. Mottled, dorsolateral stripes, picket, mid-dorsal stripe, pelvic spots.

E. nubicola. Mottled, dorsolateral stripes, picket, mid-dorsal stripe, broad mid-dorsal stripe, pelvic spots.

E. alticola. Mottled, dorsolateral stripes, mid-dorsal stripe.

E. junori. Mottled, dorsolateral stripes, mid-dorsal stripe, interocular bar.

E. andrewsi. Pelvic spots.

E. fuscus. Mottled.

I have seen all of these patterns in their pure form in the species listed above except picket pattern in *gossei*. I have seen specimens of *gossei* which have a pattern somewhat like picket but certainly not the same clear-cut pattern exhibited by *pantoni* and *nubicola*.

When the presence of these various patterns in the species is correlated with the suggested evolutionary history presented above, a rather striking fact stands out—that, as we pass from the rather generalized parent stocks to the more specialized filial species, there is a reduction in the number of color patterns present. Furthermore, the patterns that drop out or become fixed are not necessarily the same in the different evolutionary lines so that whereas we have the generalized *gossei* with many patterns, *alticola*, at the terminus of one evolutionary line, retains only mottled, dorsolateral stripes and mid-dorsal stripe, and in *andrewsi*, at or near the terminus of another evolutionary line, every known specimen shows only pelvic spots.

E. nubicola, which I have assumed to be between *gossei* and *alticola*, has six of the eight patterns shown by *gossei* and has none that are not present in *gossei*; and *alticola* has three of the six present in *nubicola* but none that are not present in *nubicola*. Along the other line, *pantoni* has five of the eight patterns present in *gossei* but none not present in *gossei*; *junori* has three present and one not at present known in *pantoni*; finally, as mentioned above, the pattern of pelvic spots seems to be fixed in *andrewsi*.

The three known specimens of *fuscus* are all mottled.

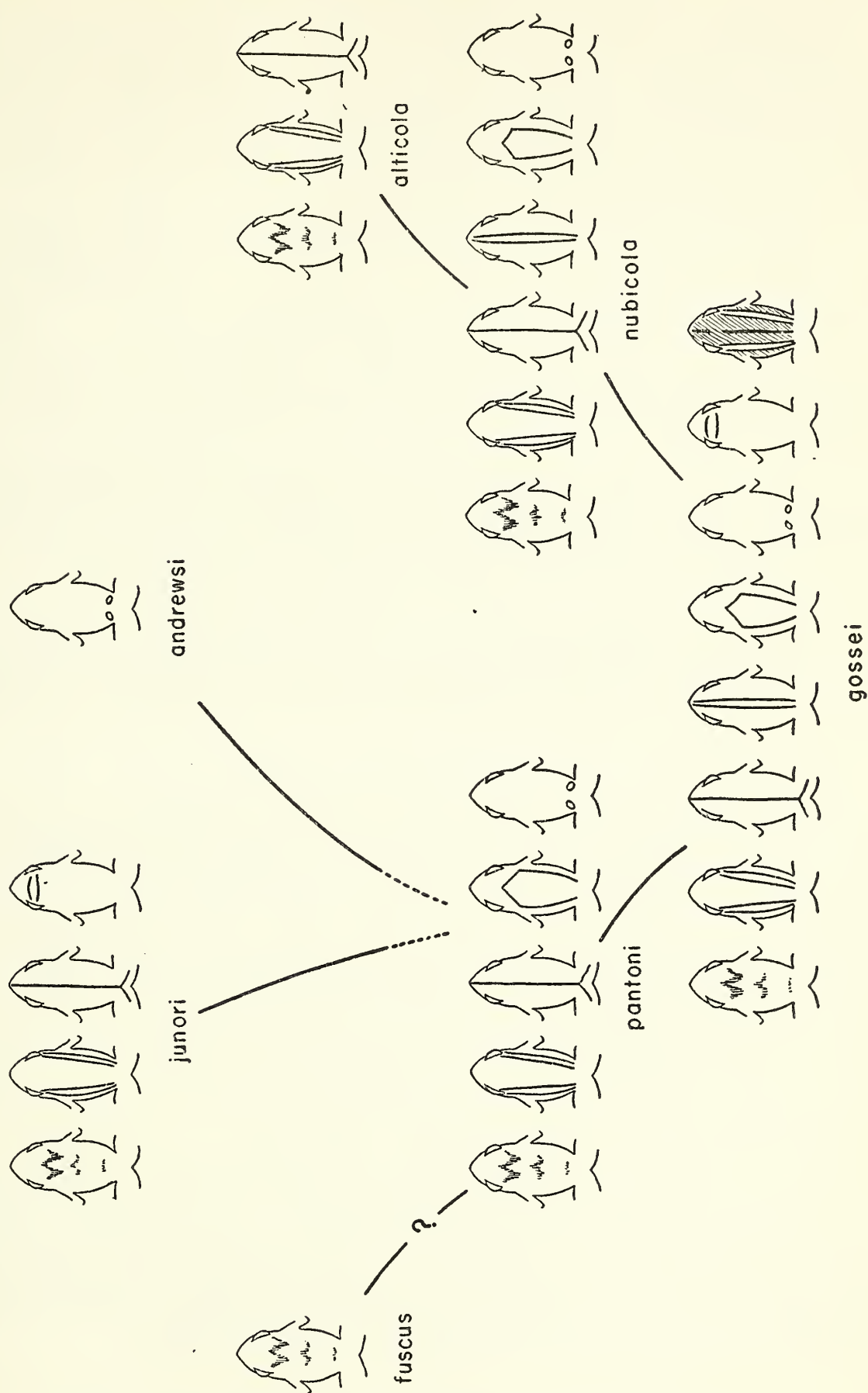


FIG. 2. SUGGESTED PHYLOGENY OF COLOR PATTERNS IN THE *gossei* GROUP OF THE FROG GENUS *Eleutherodactylus*.

The patterns present in the various species can then be superimposed on the evolutionary history present in Fig. 1 as shown in Fig. 2.

Although the details of the evolutionary history are, and must remain, open to interpretations somewhat different from those I have given them, I do not believe that there can be much doubt that:

1. The species (*gossei*) showing the greatest degree of polymorphism is the most generalized.
2. The species (*junori*, *andrewsi*, *alticola*) that show the least degree of polymorphism are specialized.
3. The same patterns do not occur in all of the more specialized terminal species.

It is true, as Wright (1940: 181) has said, that there is no necessity for supposing that evolution has proceeded in the same way in all groups. It also seems to me to be equally true that there is no theoretical reason for assuming that all the characters in a single species necessarily evolved in the same way. While the information presented here may or may not have any bearing on such specific characters as voice, size, teeth, etc., it does demonstrate that insofar as color patterns are concerned, the evolutionary process in this group of *Eleutherodactylus* has tended toward a fixation of the genotype from an original, extremely variable parent stock.

In closing it should be stated that the herpetologically unexplored John Crow Mountains undoubtedly house as yet undescribed species of this group of frogs. Only time will tell how these will modify the conclusions presented herein.

ACKNOWLEDGMENTS

The initial field work for this problem was made possible by a grant from the American Academy of Arts and Sciences to which I owe my thanks. C. Bernard Lewis and Ron P. Bengry of the Science Museum of the Institute of Jamaica have been most courteous and helpful to me on more than one occasion. My field companions, Dennis E. Miller, Byrum W. Cooper and Robert H. Barth, Jr. in 1948, and Dr. Albert M. Laessle in 1952, were both helpful and tolerant. I also wish to thank Arthur Loveridge of the Museum of Comparative Zoölogy, Dr. Doris M. Cochran of the United States National Museum, Charles M. Bogert and Mrs. Bessie M. Hecht of the American Museum of Natural History, for the loan of, or permission to study, specimens in their respective collections. I am particularly indebted to Dr. W. Gardner Lynn, who introduced me to this group of frogs, who has always made his material readily available to me, and who has otherwise let me profit by his experience with the group. Finally, I wish to thank George R. Cooley for making possible my field work in Jamaica in the summer of 1952 and for his generosity which assured that every facility for traveling and collecting over the Island was at my disposal. To all of these, and others not mentioned, I owe my thanks.

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V. 33

**ART. 11. GEOGRAPHIC DESIGNATION OF THE MEMBERS
OF THE CHADRON FORMATION IN SOUTH DAKOTA**

By JOHN CLARK
Princeton University

In 1937, I recognized three members of the Chadron formation of South Dakota* which were locally identifiable by their lithology. At the time, it seemed inadvisable to give these members geographic names, because they were recognizable only locally. The designations A, B and C and 1, 2 and 3 had already been used for purely faunal subdivisions known to be invalid, so I used the names Lower Member, Middle Member, and Upper Member. Work on lower Oligocene sediments in other localities has necessitated occasional references to these members and confusion has arisen as to whether, for instance, the expression "older Chadronian" means "coeval with the Lower Member of Clark 1937" or simply "older part of the early Oligocene." Personally, I do not approve of geographic names for thin, local members of formations, but the overwhelming majority of vertebrate paleontologists favor geographic names in this case. I, therefore, wish, at this time, to designate a standard section for the Chadron formation in South Dakota with geographic names for its members.

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These last two names are the alternative local names given to the prominent butte in the southern part of Sec. 10, T.4S., R.12E., which is called both "Crazy Johnson Butte" and "Peanut Peak", referring to attempts by a man named Johnson to raise peanuts on top of it. The standard section for these two members is the north face of this butte, illustrated in Plate XXI, upper figure, of the Annals of the Carnegie Museum, v. 25, art. 21, referred to above.

It is obvious that more widely used geographic names would be preferable to these. However, the three members are all fossiliferous and are most characteristically developed at this locality, and no other geographic names are available here. It seems advisable, therefore, to let geologic practicability override euphony and lexicographic elegance in this case.

In the original definition of the three members, the Ahearn (Lower) member was described as characteristically including red sediments. It was assumed that all of these reds were inherited, either from a lateritic soil on the uplands or from the Spearfish and Opeche formations of the Black Hills.

*J. Clark. The stratigraphy and paleontology of the Chadron formation in the Big Badlands of South Dakota. Annals of the Carnegie Museum, 1937, v. 25, art. 21, p. 261-350.



Careful restudy has confirmed the presence of inherited reds in clay pebbles and small laminae interbedded with greenish sediments. However, small hematite concretions also occur, with ramifying extensions which could not have undergone transportation. Also, in some cases a red-stained zone of hematite concentration surrounds bone inclosed in even-grained, otherwise green sandstone. It is evident, therefore, that both inherited and epigenetic reds occur within the Ahearn member. The diagenetic nature of the red-orange color in the Peanut Peak and Crazy Johnson members has been further confirmed by recent field studies; it is apparent that three different types of red beds are represented in the Chadron of South Dakota.

In the original paper, bentonitic material was not reported for the western-derived Chadron sediments (p. 284). It was first detected by Ray Alf, now of Webb College, California, who wrote an unpublished paper on the subject. I have since confirmed Mr. Alf's observation. All three members contain ash, which differs from the ash of the overlying Brule in being completely bentonitic, while the Brule ash consists partly of fresh shards.

Additional information and interpretation will be presented in a forthcoming paper on the faunas of the three members.

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ART. 12. A NEW WASP OF THE GENUS *HABRITYS*
(PTEROMALIDAE; HYMENOPTERA) FROM WISCONSIN
AND NEW YORK

BY GEORGE WALLACE

Two specimens of an apparently new species of Pteromalidae were noted briefly by the author in 1941 in the collection of the American Museum of Natural History. More recently a larger series of specimens was found in the collection of the University of Wisconsin. Examination of the combined materials has clarified the generic placement of the species, and following is the description of the new chalcidoid.

Habritys latrus sp. nov.

Female. Length 1.7 mm. Head wider than thorax, and a little more than twice as wide as thick; vertex broad, temples not receding; occiput immargined. Postocellar line slightly shorter than the ocellocular line. Head height, measured clypeus to vertex, approximately $\frac{2}{3}$ of head width. Anterior margin of clypeus straight, and forming a sulcus-like angle with the swollen portion immediately above. Ocelli round, placed at an angle with the dorsal plane of the head. Distance from lower margin of eye to base of mandible equal to more than $\frac{1}{2}$ the length (greatest diameter) of the eye. Cheeks not excavated. Face swollen below antennal insertions. Mandibles both tridentate, the teeth long and acute. Maxillary palpi 4-jointed; labial palpi 3-jointed, the second and third joints short and thicker than the first, the terminal joint pointed. Antennae inserted just above a line connecting the lower margins of the eyes, with three ring-joints. Scape convex inwardly, outer sides straight, not reaching the level of the anterior ocellus, equal to $\frac{3}{5}$ the length of the flagellum; scrobes shallow, not margined; pedicle equal to $\frac{1}{3}$ the length of scape; funicle joints about $\frac{1}{3}$ as long as wide, increasing somewhat in size from 2 to 5; club slightly wider than last funicle joint; equal in length to the preceding three funicle joints. Prothorax transverse, declivous, but without a distinct anterior carina; posterior border polished, close-fitting. Parapsidal furrows weakly indicated anteriorly; axillae well separated. Scutellum without cross-furrow. Propodeum short, the neck small; lateral and median carinae present; spiracle rotund; sides of propodeum with only a few hairs. Discal cilia of the upper side of fore wings mostly lacking in costal cell and in area immediately behind submarginal vein. Marginal and postmarginal veins subequal, the marginal being slightly the longer; submarginal about twice the length of the marginal. Stigmal vein about $\frac{3}{5}$ the length of the marginal, knob normal. Anterior and posterior femora swollen. Anterior and posterior tibiae pubescent and widening apically, this particularly noticeable in the anterior tibiae. Anterior tibiae and femora approximately equal in length; posterior femora about $\frac{4}{5}$ the length of posterior tibiae. Posterior tibiae 2-spurred. Abdominal petiole smooth, slender; length, as seen from above, less than diameter. Gaster flat beneath and above, a little longer than wide, about equal in length to thorax; apex rounded; ovipositor



not exerted, ovipositor sheaths, viewed from below barely visible. Basal tergite extending $1/3$ length of abdomen, with a slight incision medially; tergites 2-4 subequal in length.

Head and thorax, including propodeum, reticulate-punctate, the punctation weak in the cheeks and clypeal area. Posterior coxae with some feeble reticulations; tergites polished, marked with very faint wavy lines. Color of head and thorax dark green above, shading to black on under side of thorax and on face and cheeks; abdomen dark brown. Scape, pedicel and ring-joints pale testaceous; funicle darker; club brownish. Mandibles brown, blackish at base. All legs pale testaceous except femora and coxae; femora more suffused with brown; coxae brown.

Male. None seen.

Type locality. Madison, Wisconsin.

Holotype and eight paratypes, University of Wisconsin. Two paratypes, United States National Museum. Two paratypes, Carnegie Museum. The foregoing type specimens comprise a lot of 13 specimens reared from stems of *Rhus hirta* by J. G. Sanders, "3-10-11, Wis. Exp. Sta. Acc. No. 236." Also two paratypes, American Museum of Natural History; these two specimens reared from nest of *Ceratina dupla* (Hymenoptera) Nyack, New York, July 2, 1884.

Fig. 1 shows head and venational characteristics.

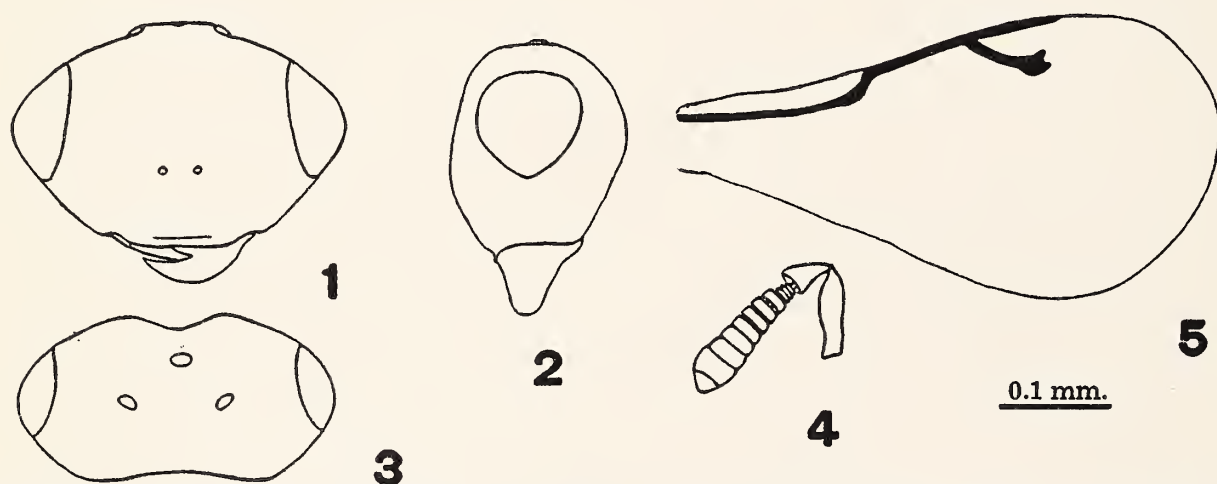


FIG. 1. *Habrityx latrus* Wallace. 1. Head, front view, antennae removed. 2. Head, side view, facing left. 3. Head, dorsal view. 4. Antenna. 5 Right wing.

From *H. brevicornis* (Ratzeburg), a European species, this new species may be separated by its smaller size, swollen face, carinate propodeum, lack of a definite cross-line on the scutellar punctation, and the flat, almost rotund gaster.

I have not seen specimens of *H. bimaculatus* Brèthes,* but, judging from the description of the species, I doubt if it should be placed in this genus.

* J. Brèthes, *Anales del Museo Nacional de Historia Natural de Buenos Aires*, 1915, v. 27, p. 418.

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ART. 13. SKULL VARIATION IN THE MEADOW VOLE
(*MICROTUS P. PENNSYLVANICUS*) IN PENNSYLVANIA

BY DANA P. SNYDER

INTRODUCTION

The delimitation of mammalian subspecies is quite generally based on proportional or absolute size differences as well as on qualitative characteristics which can not be readily measured with objectivity. There has, however, been some question whether such quantitative differences always supply valid evidence of genetic variation between two populations (Huxley, 1932; Reeve, 1940; Tryon, 1951). It is, of course, widely recognized that absolute size can be affected by environmental as well as by genetic factors, but it is perhaps less clearly realized that the ratio between two dimensions may be likewise unreliable. Such ratios may vary as the absolute size varies, and since we can not always evaluate size variation in terms of causal factors neither can we interpret the differences in proportions. Valid comparisons of proportions should take into account any differences in absolute size.

Opportunity for a study of this problem in relation to geographic variation has been provided by recent collections of mammals in Pennsylvania. The meadow vole, *Microtus p. pennsylvanicus*, is particularly well represented in the collections and has furnished the material on which this report is based. Only quantitative characters, chiefly skull dimensions, have been used; although in some preliminary treatment external measurements and weights were also analyzed. This report is concerned primarily with the amount and nature of the variation rather than with its cause.

The material studied is a part of the mammal collection of Carnegie Museum. Most of the specimens were collected by the Survey of Pennsylvania Mammals, a series of six Pittman-Robertson Projects (no. 20-R, 24-R, 37-R, 38-R, 42-R, and 43-R) conducted under the Federal Aid to Wildlife Restoration Act of 1937. The survey was a co-operative effort among the Pennsylvania Game Commission, the U. S. Fish and Wildlife Service, and Carnegie Museum. A final report has been published on each of the Pittman-Robertson Projects (Richmond and Rosland [sic] 1949; Grimm and Roberts, 1950; Roslund, 1951; Gifford and Whitebread, 1951; Grimm and Whitebread, 1952; Roberts and Early, 1952).

I wish to thank Dr. J. Kenneth Doult, Curator of Mammals, Carnegie Museum, for many helpful suggestions and criticisms during the study. For much valuable aid I am indebted also to Miss Caroline A. Heppenstall, Assistant Curator of Mammals, and John E. Guilday, Assistant Curator of Comparative Anatomy. Discussions with members of the biostatistics staff of the University of Pittsburgh School of Public Health have been most valuable to me. I should particularly like to thank Dr. D. G. Horvitz, Dr. D. J. Thompson and Dr. C. C. Li for their kind assistance. Responsibility for any errors or for any question of interpretation of results is, of course, mine. The illustrations were very ably drawn by Clifford J. Morrow, Jr. and by Charles L. Ripper. Cambridge University Press very obligingly allowed me



to quote from D'Arcy Thompson's "On Growth and Form." The quotation from "Growth in the Snout of Anteaters" is by permission of the Zoological Society of London.

NON-GEOGRAPHIC VARIATION

MEASUREMENTS

Weight and external measurements are those taken by the collector. Skull dimensions were recorded to the nearest 0.1 millimeter by means of dial calipers. Measurements were taken as described below and illustrated in Fig. 1. Paired structures were measured on the left side.

1. Greatest length of skull: maximum distance between the occipital condyle and the most anterior point of incisor.

2. Condylzygomatic length: distance between occipital condyle and antero-superior edge of zygomatic process of maxilla.

3. Length of nasal: maximum length of nasal bone.

4. Length of incisive foramen: maximum length of palatine slit.

5. Length of diastema: distance from posterior edge of incisive alveolus to anterior edge of alveolar space of molar row.

6. Length of rostrum: dimension obtained by subtracting condylzygomatic length from greatest length of skull.

7. Cranial breadth: distance between outer surfaces of the small squamosal bars (which form the ventral borders of the prelamdboidal fenestrations) taken at the point where, viewed perpendicularly from above, these bars pass beneath the overlying portion of the squamosal bone.

8. Interorbital breadth: least diameter of frontal bones between the orbits.

9. Zygomatic breadth: maximum spread of zygomatic arches.

10. Cranial height: perpendicular distance from highest point of parietals to a plane passing from most inferior point of auditory bullae along crown of most prominent molar (cf. Howell, 1924). To obtain this measurement the skull was placed on a glass plate as in Fig. 1, and the distance recorded from bottom of plate to dorsal-most portion of skull. The thickness of the plate was then subtracted to give the height.

SOURCES OF VARIATION

Considerable variability is found within samples from single localities. Two of the factors (age and sex) contributing to this non-geographic variation can of course be readily recognized and taken into account when populations from different localities are compared. Although variation due to sex can be completely eliminated (assuming correct sexing by the preparator), that resulting from age differences can usually be reduced only to some minimum value by grouping the specimens into narrow age ranges. The remaining variability, usually termed individual variation, perhaps reflects some local environmental differences (including seasonal differences in the environment) as well as the genotypic differences to be expected in a wild interbreeding population. The average value of this individual variation *within* each of two (or more) populations serves as a yardstick in determining the significance of the geographic variation *between* the populations.

Age variation. Howell (1924) in a study of individual and age variation in a local population of *Microtus montanus* found condylobasilar length to be the most satisfactory criterion on which to base a consecutive arrangement of the skulls in order of increasing development. Such a series can be arbitrarily divided into size groups which probably, in general, correspond to age groups. Such an arrangement based on a size measurement, although suitable for determining individual variation, is less desirable in a study of geographic variation. The character used (e. g. skull length) would be held constant, or at least be non-randomly selected, in samples being compared,

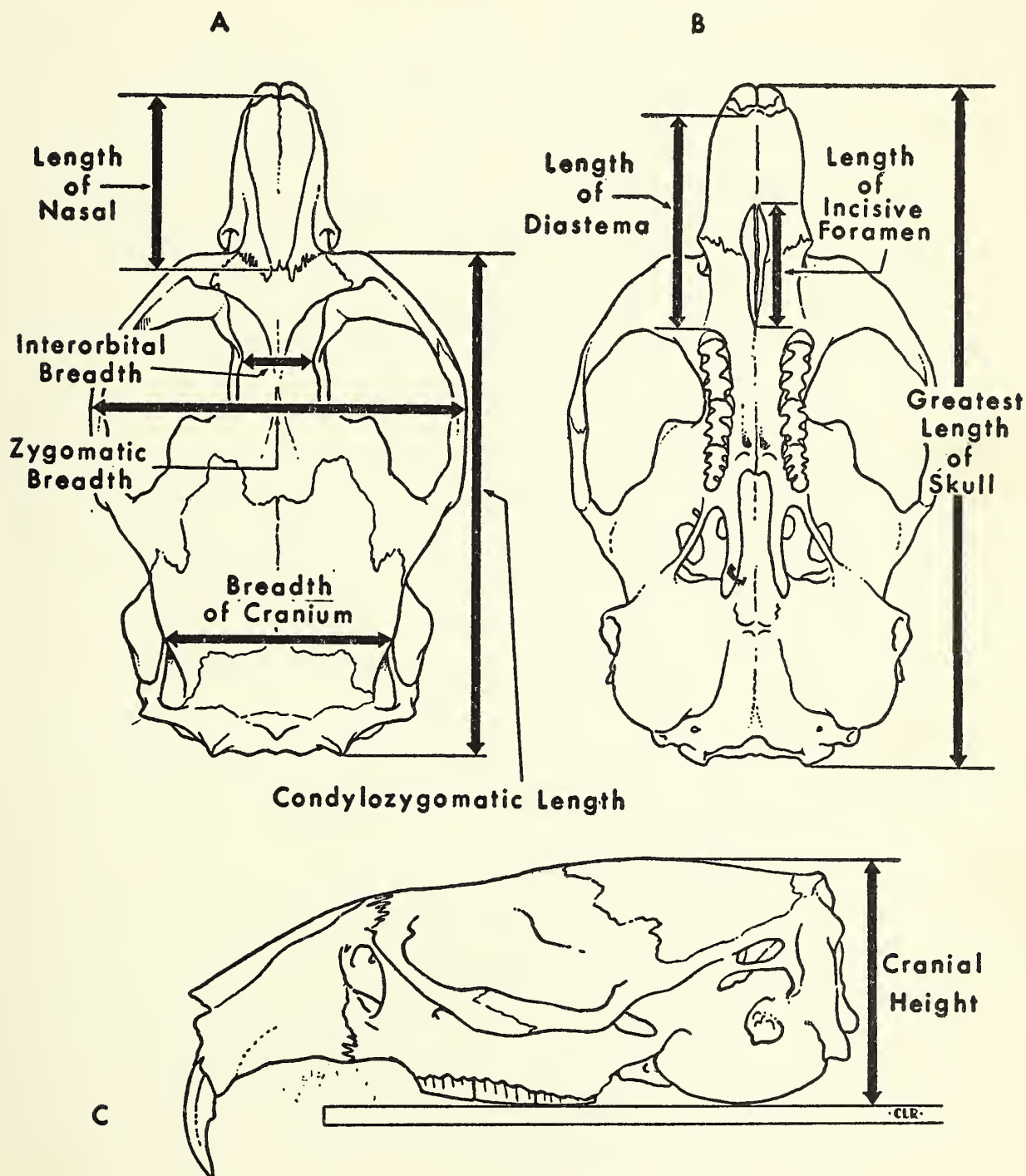


FIG. 1. Dorsal (A), ventral (B), and lateral (C) views of skull of *Microtus p. pennsylvanicus* illustrating dimensions explained in text.

and therefore no valid indication of geographic variation in this measurement could be obtained. Furthermore, conclusions regarding variation in other characters correlated with skull length would be open to question. As will be brought out later, it is desirable to compare samples in which one dimension, such as total length of skull, remains constant throughout. But it is well first to determine the actual geographic size variation among the populations and then to use more precise mathematical methods in reducing one dimension to a constant value for further investigations of variation in relative dimensions.

A more satisfactory aging method for some groups of mammals is the order and degree of suture closure and the development of crests and local prominences (See Doult, 1942 and references therein). Sutures, however, have not been of much aid in meadow voles because some suture lines disappear quite early while others remain apparent even in the oldest individuals available. To obtain satisfactory age groupings, it has, therefore, been necessary to rely on changes in characters which are more subjective in interpretation. Three characters, lambdoidal crest, mastoid-exoccipital crest, and paroccipital process, were finally selected for this purpose. In young animals the paroccipital process closely follows the curve of the auditory bulla but later becomes directed posteroventrally. In each skull examined the position of this process was assigned an arbitrary value of two, three, or four in order of increasing development. Similarly, each crest was given a value from one, representing least development, to four, showing maximum development. The three index figures thus assigned to each skull were then totaled to determine the age group to which the specimen belonged. There resulted nine such groups, the youngest represented by four (the smallest possible total value) and the oldest by 12 (the largest possible total value). These numbers representing the total values will hereafter be used to refer to the respective age groups. Although this method is subjective, the results should be comparable for all specimens studied by one worker.

It is possible that individual variation in these skull characters used to determine the relative age may be such that a wide age range is included in each age group with a consequent broad overlapping of actual ages from one group to the next. This condition, if subsequently found to be true, would not necessarily invalidate the method because the sample groups would still be statistically and biologically comparable under the assumption that for any given age group all samples would be normally distributed with the same actual mean age. In this event the variability due to age within each group would, however, be higher than desirable.

The mean and the range of greatest length of skull for the age groups 7 through 12 for a series from northwestern Pennsylvania are shown in Fig. 2. The age groups 4, 5, and 6 obviously represented quite young animals and were not used here or in further analysis. The successive increase in the mean from the youngest to the oldest groups, although it does not eliminate the possibility of overlap pointed out above, does indicate that the method gives an approximate age arrangement of the specimens. On the basis of the considerable individual variation indicated by the range of each

sample, it seems doubtful that a grouping on the basis of skull length would give a better approximation to the true age than the method employed here.

A further analysis was made of skull and external characters to determine which are least variable with respect to age. This analysis was based on a series from one locality (Pymatuning Swamp, Crawford County) in which

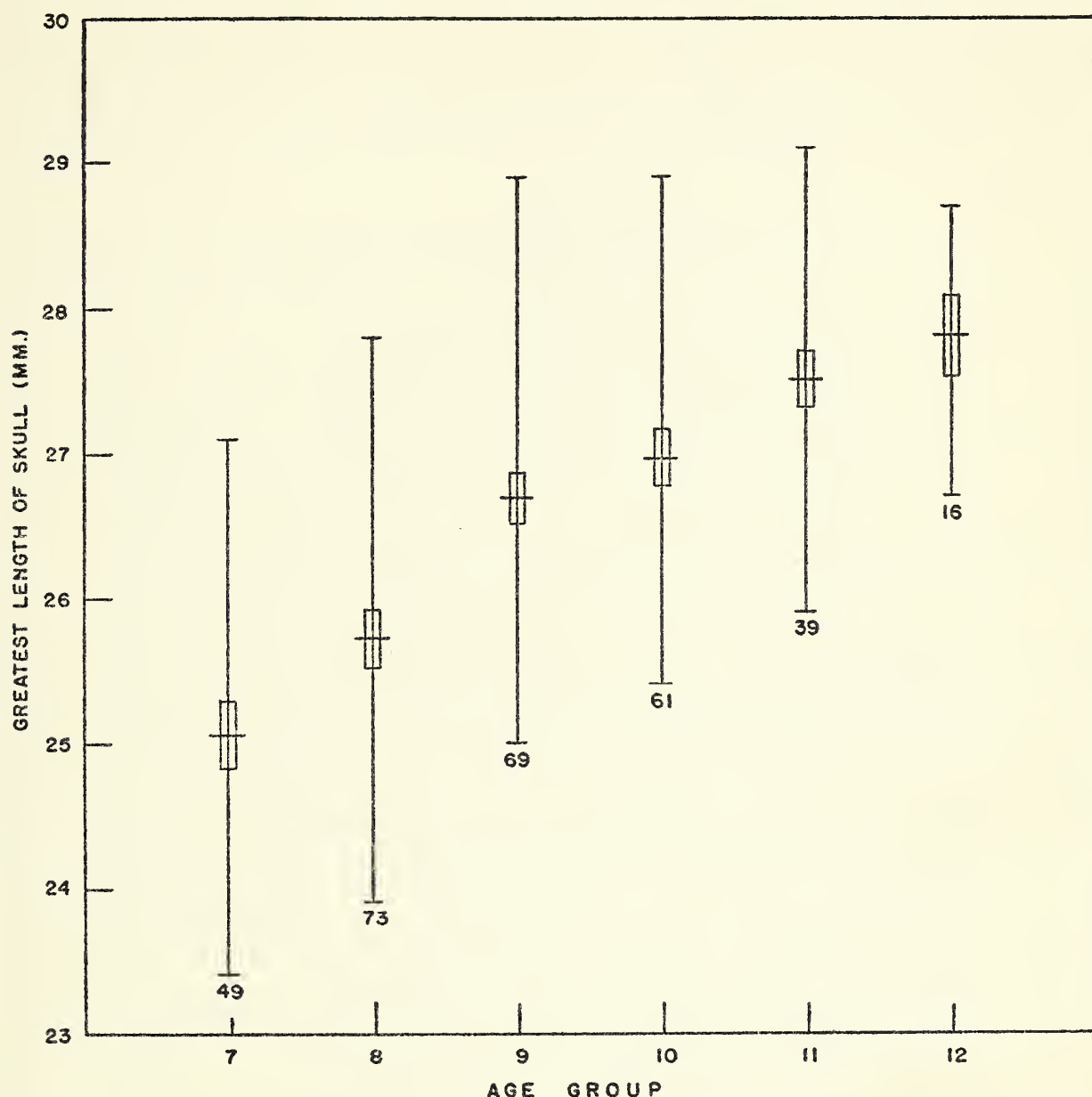


FIG. 2. Skull length of *Microtus p. pennsylvanicus*, age groups 7 to 12, males and females combined, from northwestern Pennsylvania. Range shown by light vertical line; number of individuals in sample by figures below this line; closed rectangle indicates two standard errors on each side of mean which is represented by the heavy horizontal line.

all age groups from seven to twelve were fairly well represented. Fig. 3 shows, for each character measured, the percentage of adult size (assumed to be represented by age groups 11 and 12) which specimens have reached at the earlier ages. Mean values are used in each case. Each plotted point is based on 12 or more specimens except for cranial height where because of damaged bullae, the number available was less ranging from 5 to 12 at

the various age levels. This graphical method is one developed by Simpson (1941) and the reader is referred to his paper for further explanation. It can be readily seen that cranial height, cranial breadth, and interorbital breadth approach their maximum development at an earlier age than do the other skull characters studied. Of the external measurements, ear and length of hind foot approach adult size earliest, and all four are essentially of adult size by age group 10. For external measurements, age group 10 should therefore be averaged with groups 11 and 12 in determining the base-line for adult size. However, this is unnecessary for the present purpose since the relative position of the other age groups would be only slightly affected.

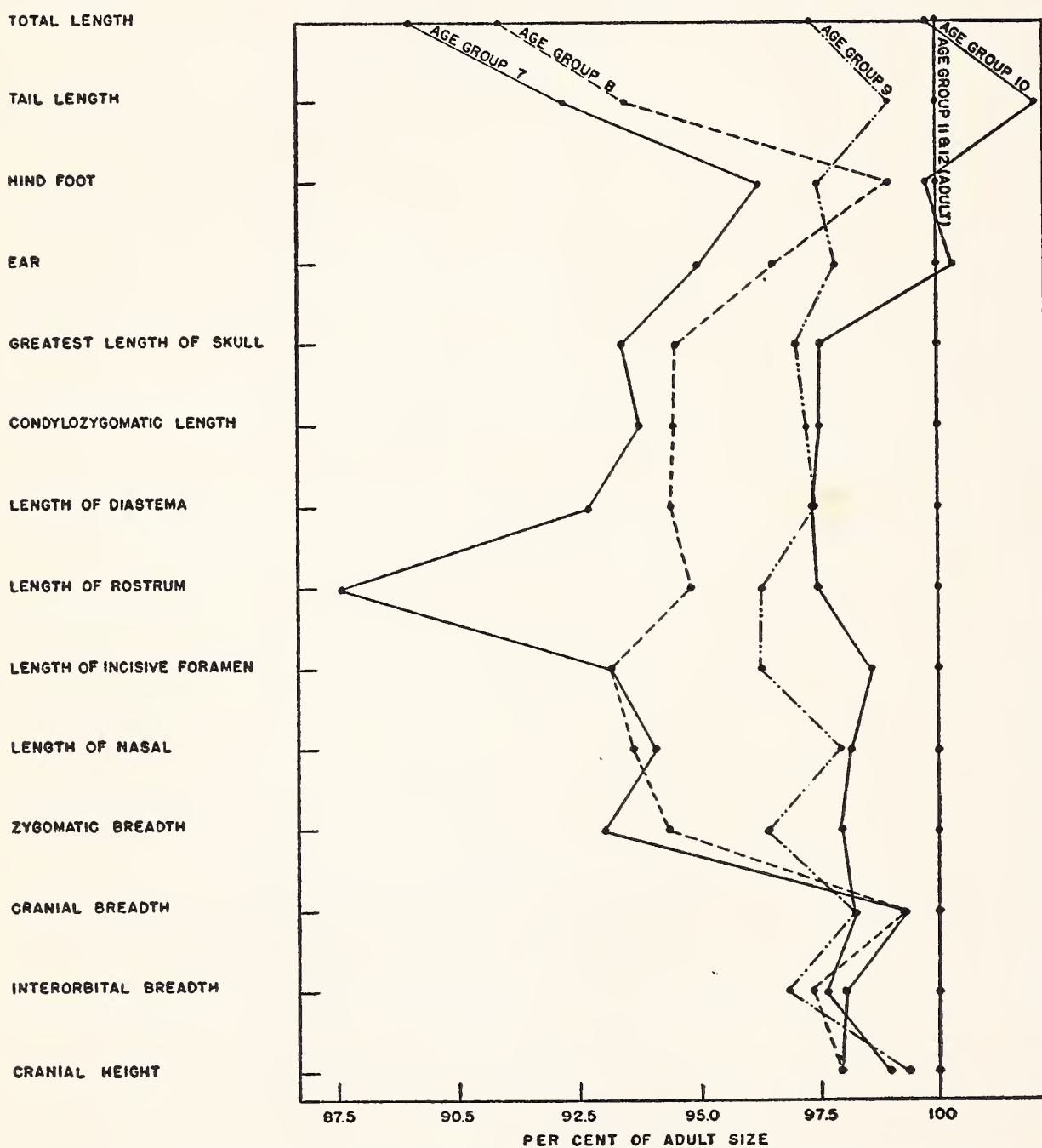


FIG. 3. Percentage of adult size (age groups 11 and 12) reached by *Microtus p. pennsylvanicus* (sexes combined) at earlier ages. Mean values of the dimensions at each age level were used in plotting.

TABLE 1

External and skull measurements, in millimeters, of *Microtus p. pennsylvanicus*, age groups 9-12, from Pymatuning Swamp, Crawford County, Pennsylvania. s_d is the standard error of the difference.

	MALES				FEMALES				MEAN ♂—MEAN ♀ s_d
	Number in sample	Mean	Standard deviation	Coefficient of variation	Number in sample	Mean	Standard deviation	Coefficient of variation	
Total length	38	167.4 ±1.2	7.4	4.42	26	164.4 ±1.7	8.5	5.17	+1.50
Tail length	38	44.4 ±0.9	5.7	12.84	26	44.1 ±0.8	4.2	9.52	+ .23
Hind foot	60	20.6 ±0.1	0.8	3.88	49	19.9 ±0.1	1.0	5.03	+4.06**
Ear	38	14.0 ±0.2	1.0	7.14	26	13.8 ±0.2	1.0	7.25	+0.78
Weight	22	44.19±1.34	6.29	14.23	11	43.96±3.09	10.25	23.32	+0.08
Greatest length of skull	34	27.35±0.11	0.63	2.30	24	26.80±0.13	0.63	2.35	+3.28**
Condylzygomatic length	34	21.31±0.09	0.52	2.44	25	21.00±0.11	0.55	2.62	+2.20*
Length of nasal	30	7.70±0.08	0.42	5.45	22	7.60±0.06	0.26	3.42	+0.99
Length of incisive foramen ..	37	5.21±0.05	0.28	5.37	26	4.99±0.05	0.27	5.41	+3.12**
Length of diastema	37	8.34±0.04	0.27	3.24	26	8.08±0.06	0.30	3.71	+3.55**
Length of rostrum	34	6.04±0.04	0.23	3.81	24	5.81±0.05	0.23	3.96	+3.74**
Cranial breadth	52	11.03±0.04	0.29	2.63	46	10.95±0.04	0.28	2.56	+1.37
Interorbital breadth	58	3.66±0.02	0.12	3.28	49	3.63±0.02	0.16	4.41	+1.10
Zygomatic breadth	33	15.23±0.08	0.47	3.09	27	14.98±0.09	0.48	3.20	+2.03*
Cranial height	23	10.07±0.06	0.27	2.68	20	10.06±0.07	0.29	2.88	+0.12

*Probability between 5% and 1% levels
**Probability beyond 1% level

Secondary sexual variation. Sexual differences in absolute size in the Pymatuning Swamp specimens, shown in Table 1, are significant (probability between 5% and 1% levels) or highly significant (probability beyond 1% level) for several characters—length of hind foot, greatest length of skull, condylozygomatic length, length of incisive foramen, length of diastema, rostral length, and zygomatic breadth. For the measurement of length of skull, an analysis of variance between sexes was made using a total of 150 specimens from a number of localities in northwestern Pennsylvania. A mean difference of approximately 0.4 mm. was found to be highly significant throughout the area. On the basis of this information it seemed best to treat the sexes separately, and in further analysis of the data only males are used.

Individual variation. Individual variation in size, as indicated by the coefficient of variation was also determined for the series from Pymatuning Swamp. The results, given in Table 1, indicate the same relative variability as found by Goin (1943) for specimens from this area. The absolute values of the figures shown, however, are considerably lower than hers probably because of the more restricted age range of my samples.

The least variable skull measurements are the following—greatest length of skull, condylozygomatic length, cranial breadth, cranial height, and zygomatic breadth.

GEOGRAPHIC VARIATION

LOCAL VARIATION IN ABSOLUTE MEASUREMENTS

As a preliminary step in the analysis of state-wide variation, a study was made of local variation within a relatively small geographic area in northwestern Pennsylvania. In order to reduce age variation to a minimum and still obtain samples of sufficient size, it seemed desirable on the basis of the results shown by the graph (Fig. 3) to include only age groups 9 through 12 in each sample for all measurements except cranial height, cranial breadth, interorbital breadth, and length of hind foot. For a comparison of the latter characters age groups 7 through 12 were included. The variation contributed by this age spread was assumed to be sufficiently small so that any geographic variation present would not be obscured even though the age composition of each sample might be slightly different. Satisfactory samples were thus obtained from seven areas in northwestern Pennsylvania. These are indicated on the map (Fig. 4) by a solid circle where all specimens were taken at one locality and by an open circle in those cases where specimens were taken at a number of adjacent localities. Physiographically, two of the areas, A₁ and A₂, are situated on the lake plain of the Central Lowland Province; the other five are on the Appalachian Plateau. All are in regions which have been changed ecologically by agricultural activity. The meadow vole is distributed generally throughout this part of Pennsylvania being taken in fields, both cultivated and abandoned, and in grassy or marshy places which occur in low spots and along streams. Some of the habitat in the Crawford County area has been changed by the creation of Pymatuning Reservoir since the specimens were collected there.

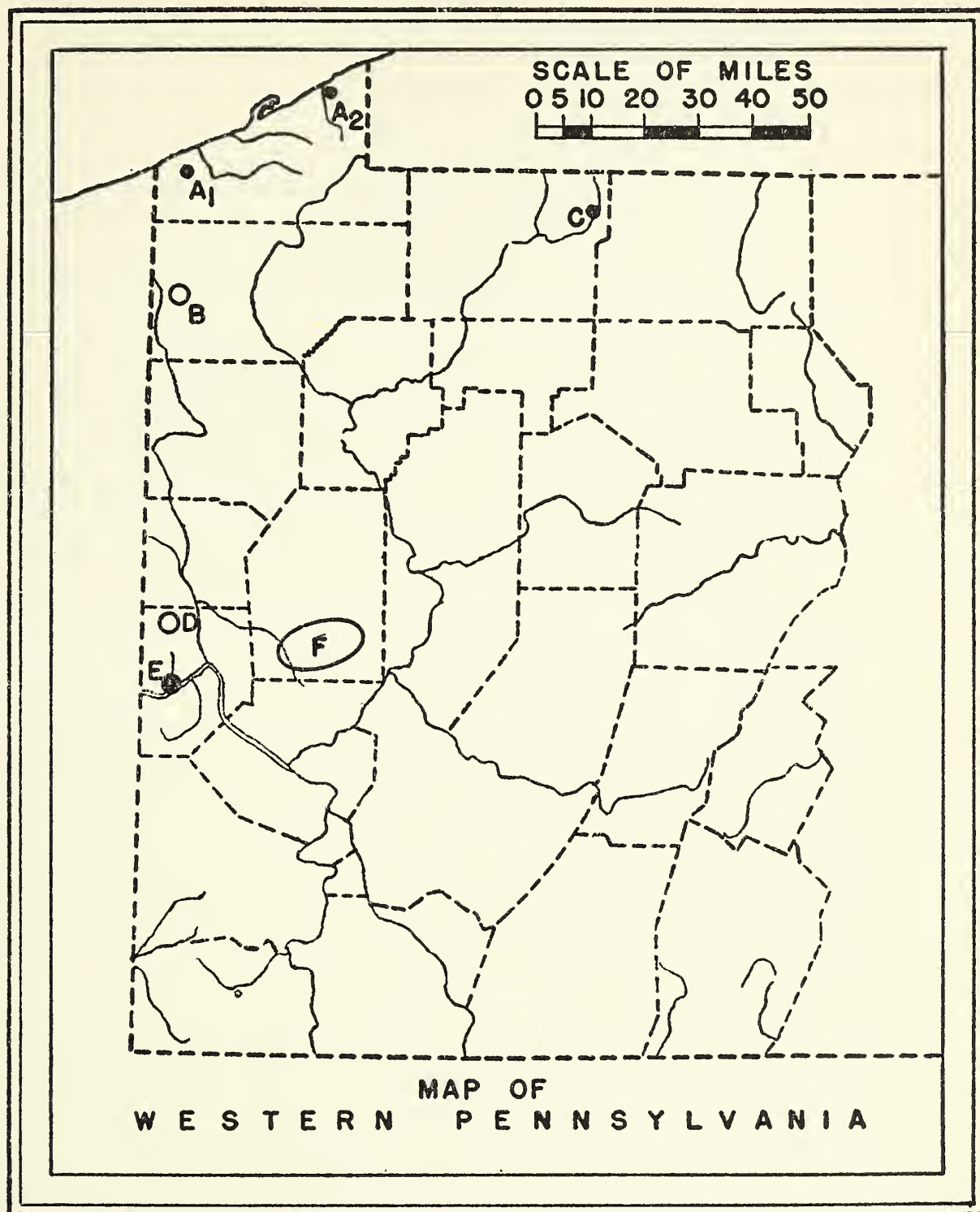


FIG. 4. Collecting areas represented by the seven samples used in analysis of local variation in *Microtus p. pennsylvanicus* in northwestern Pennsylvania. A₁, Erie Co., East Springfield; A₂, Erie Co., 4½ mi. SW. of Northeast; B, Crawford Co., Linesville, 4 mi. SE. of Linesville, 2 mi. SW. of Linesville; C, Warren Co., 2½ mi. N. of Kinzua; D, Beaver Co., ½ mi. NW. of New Galilee, 1 mi. NE. of Darlington; E, Beaver Co., 2 mi. E. of Industry; F, Butler Co., 2 mi. E. of Mars, 3 mi. E. of Mars, 2 mi. W. of Saxonburg.

The variation in skull length among these seven areas is shown in Fig. 5. It is obvious that considerable geographic variation occurs between areas which are quite near each other. Areas D, E, and F are all within a radius of 15 miles. It is also apparent that not all populations show such variation, even though they may be separated by greater distances. The variation in skull length as well as in a number of other dimensions was tested by an analysis of variance. The resulting ratios given in Table 2 show that, with the exception of cranial breadth and cranial height, variation within the area is highly significant. There is, accordingly, little reason to doubt the reality of appreciable phenotypic variation among populations within this relatively small area. Similar local variation has been notably demonstrated in *Peromyscus* (Sumner, 1932; Dice, 1940) as well as in many other diverse species of animals. Whether these differences are genetic, resulting from random gene fluctuations or from evolutionary pressures operating in slightly different environments, or whether they are non-genetic direct phenotypic expressions of environmental differences can not be readily determined. The studies of Sumner and of Dice cited above indicate that such differences may be hereditary. Tryon (1951) after an analysis of populations of pocket gophers in Montana believed that differences in length of skull might correctly be attributed to the effect of environment acting within genetic limits, but he also found evidence that some differences between local adjacent populations might be the result of reproductive isolation. It would seem most likely that both genetic and environmental differences are acting together to produce these populations showing morphological variation. Thus, an important problem is the partitioning of the observed variance into that portion caused by genotypic and that by environmental differences. If we are to base taxonomic conclusions on genetic as well as on morphological similarities or differences, it will eventually be necessary to discover the respective effects of environment and heredity in each situation studied. Such partitioning of the variance observed in wild populations is likely to be a difficult problem but should, nevertheless, prove a fertile field for investigation. For one approach to this problem see Hayne (1950).

It should be mentioned here that the season of collection might have affected the means of the samples. The method of age grouping employed would tend to offset differences of age composition of the populations from season to season, but even with voles of similar age, there could be phenotypic effects of seasonal environmental differences. In the samples at hand, however, there seemed to be no clear-cut relationship between the means and date of collection. In the graph (Fig. 5) some seasonal effects are no doubt confounded with geographic effects, but the latter are almost certainly significant in themselves. In any event, it was evident at this point that additional procedures would be required for a more satisfactory interpretation of the results; and the methods of covariance analysis, discussed in the following section, appear to furnish a satisfactory approach to this problem.

COVARIATION

Method and concepts. "Every growing organism, and every part of such a growing organism, has its own specific rate of growth, referred to this or that particular direction; and it is by the ratio between these rates in different directions that we must account for the external forms of all save certain very minute organisms." The foregoing statement by Thompson (1942: 82) implies that growth may be allometric and therefore that the ratio between two parts may change with age and size. This changing relationship between the dimensions of two parts was given a mathematical formulation by Huxley (1924; 1932). If x represents the size of a whole and y the size of a part, the relation between the two may be approximated by:

$$y = bx^a \dots\dots\dots (1)$$

The constant a represents the ratio between the geometric rates of growth of x and y and is termed the *relative growth rate*. Unless a is unity, growth will be allometric. The biological significance of b , which is termed the *initial growth index*, appears to be less clearly determined. Mathematically it represents the value of y when x is unity. Biologically it would seem to be a function of the ontogenetic point when growth (or a phase of growth at a given growth rate) begins in the element or dimension y ; but its validity

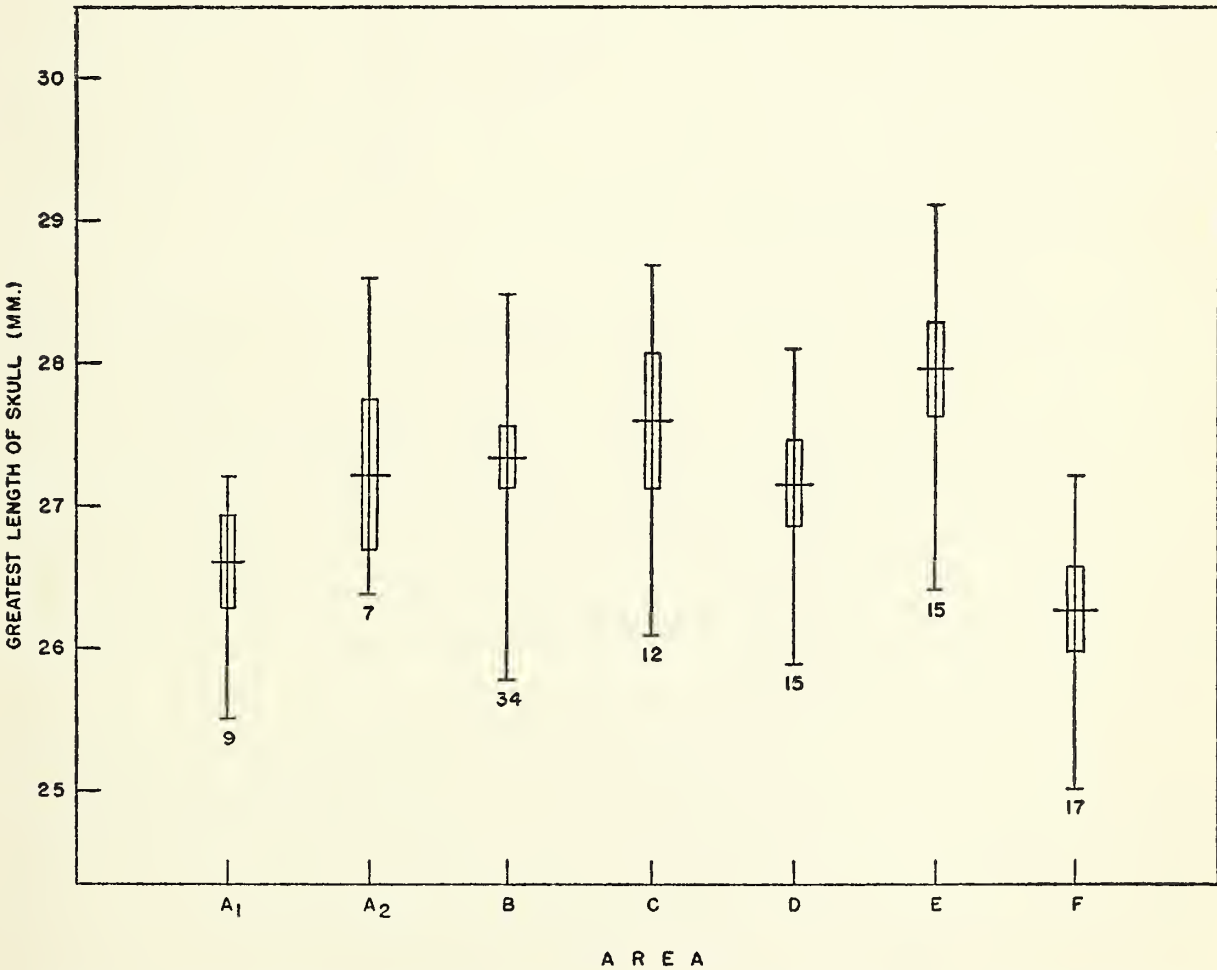


FIG. 5. Skull length of male *Microtus p. pennsylvanicus*, seven samples from northwestern Pennsylvania. Range and standard error shown as in Fig. 2.

or reality as such a constant depends on the proper choice of a unit in which to express x . Further discussion of the biological significance of these constants may be found in the work of Lumer (1936) and Lumer, Anderson, and Hersh (1942).

TABLE 2

Analysis of variance of certain dimensions in male *Microtus p. pennsylvanicus* from seven localities in northwestern Pennsylvania. F , variance ratio; n_1 , degrees of freedom for area mean square; n_2 , degrees of freedom for individual mean square.

	n_1	n_2	F
Total length	6	113	8.98**
Tail length	6	112	4.31**
Hind foot	6	202	23.57**
Ear	6	112	11.37**
Weight	6	97	8.29**
Greatest length of skull	6	102	11.40**
Condylzygomatic length	6	101	8.18**
Length of nasal	6	98	3.67**
Length of incisive foramen	6	112	5.06**
Length of diastema	6	112	12.47**
Length of rostrum	6	100	8.83**
Cranial breadth	6	174	1.50
Interorbital breadth	6	197	3.02**
Zygomatic breadth	6	103	7.20**
Cranial height	6	117	2.93*

* Probability between 5% and 1% levels

**Probability beyond 1% level

It is obvious from equation (1) that unless a has a value of one the ratio of x to y , as well as the absolute value of y , changes as x changes. This is one way in which a difference in proportions between two populations may be the result of absolute-size differences. On the other hand, the y values and consequently the ratios of x to y may differ from one population to another even though the x values are the same. This is truly a difference in proportion, not a function of size, and may result from either a difference in the relative growth rates, a , between the populations or a difference in the initial growth indexes, b , representing differences in the ontogenetic points at which growth begins.

By an analysis of covariance in which sample data from two or more populations are fitted to the curve defined by equation (1), we can determine whether or not differences exist among the populations in either the relative growth rates or the initial growth indexes. Reeve (1940; 1941) in a study of New World anteaters has demonstrated the methods for this procedure and worked out suitable probability tests. Tanaka (1952 and his earlier papers cited therein) has also used this approach in rodent systematics. Differences in relative growth rates are called by Reeve "differences in slope," and the test for their significance he termed the "slope test."

This test involves fitting the data to two sets of lines and then determining whether one set gives a significantly better fit. One set is made up of independent regression lines, one for each population. The other set is the best-fitting series of parallel lines, again one line for each population. If deviations from the latter set are not significantly greater than deviations from the former, no slope differences between the populations have been demonstrated.

The differences in initial growth indexes can not very well be tested directly since we do not know the size either at the starting point of growth or at any subsequent points when a change in rate may have occurred. Furthermore, the value of this constant, as already mentioned, depends on the unit in which it is measured and is therefore a variable figure. However, differences in values of y between samples which have the same x values and no slope differences, must be directly related to differences in the initial growth indexes. Such differences in y values can easily be calculated by the growth formula for the mean or any other specified value of x and are called by Reeve "differences in position." Accordingly the significance of these differences is determined by a "position test." The test again consists of a comparison, this time between the best-fitting set of parallel lines and the best-fitting single line. If the parallel lines give a significantly better fit, it is assumed that the means of the separate samples, which the parallel lines represent, show significant differences among themselves. Hence, since the mean of dimension x has been made the same in each sample, proportional differences may be assumed to occur among the populations. If a single line gives as good a fit as the parallel lines, there is no reason to assume such differences among the populations. In making the position test we make x the independent variable and thus eliminate all differences in this variable. Some information about variation in x is therefore unavoidably lost or covered up in order to make better use of that available with respect to y .

The position test can normally be used only when the slope test shows no significant differences in the relative growth rates. If there are growth rate differences, interpretation of positional differences becomes uncertain. The value of these tests is best indicated by quoting from Reeve (1940: 69). "It is evident from these examples that the proposed statistical tests do not make possible a full analysis of the nature of proportional differences between groups of animals, for whereas they provide an answer to the question 'Are there significantly large differences in relative growth-rate?' the question 'Are there differences in initial organ-size?' can as a rule only be answered when no differences in relative growth-rate appear. But this limitation need not worry the systematist unduly, since he will only want to know whether his data support the hypothesis that the proportional differences between the groups of animals under comparison are merely the result of absolute size-differences. The described tests appear to be admirable for this purpose." These statistical tests described by Reeve are similar to those given by Snedecor (1946: 318 ff.) for covariance analysis, but the

terminology is different. The position test of Reeve is the same as Snedecor's test for differences in adjusted means; and Reeve's slope test is equivalent to the test for significance of regression coefficients of Snedecor. Reeve's terminology will be used in the following discussion.

Davenport (1934), Richards (1935), Bernstein (1934), and others questioned the validity of the above formula for the study of growth relationships. They held that small changes in growth rate are obscured by the methods of treatment and that the value obtained is an average one, perhaps without much significance. Richards (1935) argued that the value of a , the growth rate constant, changes frequently during the life of the individual and he presented graphs to demonstrate this. However, he gave no indication of the standard deviation of his values; in the case of the graphs dealing with rats it would seem, on the basis of the original data which he apparently used (See Moment, 1933), that the samples were rather small. If so, the fluctuations which he found in the values of a are possibly not significant. Needham (1934: 83-84) observed that in some instances deviations found in values of a lost significance when a larger mass of data was employed in the calculation. It should also be mentioned that deviations in calculated values of a can result from variation between individuals as well as between different ages in the same individual. Granted, however, that a may vary somewhat during growth and also between individuals, it can still be a reliable index of the average growth relationships between various elements at least over the period of time (age range) represented by the samples used in this study.

In 1942 Kavanagh and Richards analyzed the status of the allometric equation and discussed the suitability of the different types of data which have been used in applying the formula to growth studies. They suggested that data of the type used in the present study portray only relative size, and not relative growth since there is no time factor involved; but if we assume that a certain portion of the variation within a group of individuals of similar age results from differences in stage of development, then there is a biological time factor. Thus it should be possible to consider the values of a and b as average growth constants for the population sampled. Kavanagh and Richards recognize this possibility but do not feel it can be accepted without more investigation. This is no doubt a valid objection in growth studies, since according to Merrell (1931), a growth curve based on averages of individual observations may not be characteristic of the actual growth curve of any particular individual. Therefore, study of a curve of averages would not likely lead to an explanation of growth processes. In taxonomic study, on the other hand, the situation appears to be reversed. Here we are concerned with populations and their parameters as much as, or even more than, we are with individuals. Thus, an average growth curve is perhaps a function of gene frequency, which is a population characteristic, and is therefore more important than an actual growth curve for any particular individual.

A note of caution should be added here. Recently Zuckerman and others (1950) published a critical discussion of methods used in growth studies.

It is apparent from this series of papers that a solid theoretical basis for the explanation of growth and form is still lacking. Much of the work at this time is of an empirical nature, and it is therefore generally unsound to extrapolate very far beyond the observational data.

There remains a somewhat technical difficulty in the use of equation (1). When growth is positively allometric and continues to follow the formula, $y = bx^a$, a point can eventually be reached when y is greater than x . When only linear dimensions, taken in different planes, are compared, no problem arises. But if one linear dimension, y , is a part of the other, x , or if the mass of one part, y , is compared to that of the whole, x , the theoretical implications are obviously more complex. This difficulty could be avoided by use of the equation, $y = b(x - y)^a$. However, as Needham (1934) pointed out, growth is not infinite and eventually either the value of a changes or growth stops at the adult condition. For practical purposes the values of a determined by the two equations appear to be quite similar (Needham, 1934) and the simpler form is used in the following calculations. It should be remembered, however, that this equation will not necessarily lead to meaningful correlation coefficients in those cases where the dependent variable, y , is a part of the independent variable, x , as, for example, in the comparison of length of diastema with total length of skull.

In application of the methods to the present study the simple allometry equation (1) discussed above is assumed to be a satisfactory approximation of the average growth relationships over the ages represented by the samples used. A linear function, $y = a + bx$, could be fitted to the data with an equally good correlation in some instances. However, the use of this equation would imply that growth is never allometric, the relative growth rate, a , having a value of one in all cases, and such an assumption is unrealistic in view of much experimental evidence (Huxley, 1932; Needham, 1934; deBeer, 1940; Carter, 1951). Thompson (1942: 205-212) evidently believed that growth followed the allometric formula as an exception rather than a rule, but Bonner (1952: 136) in his essay on morphogenesis disagreed, pointing out that the equation does fit numerous and diverse instances of growth. In the present study the relatively good correlation on the basis of a linear growth relationship results from the restricted range in size of the individual specimens in the samples. With the inclusion of a greater age range (and hence greater size range) in the data, the deviation from linearity would be expected to increase.

The actual calculations were based on the logarithmic form of the formula:

$$\log y = \log b + a \log x \dots\dots\dots (2)$$

The best-fitting curve for this form of the equation may be slightly different from one derived directly from equation (1), but the discrepancy should not be great. Furthermore, if growth is multiplicative, as we must assume to use the formula at all, the logarithmic form would actually appear to be the more fundamental and therefore the correct one to use (Reeve, 1940: 57). Perhaps the logarithmic rather than arithmetic values of the measurements

tend to be normally distributed (See, for example, discussion by Teissier, 1948: 27).

The procedure is illustrated graphically in Fig. 6 in which the logarithm of length of diastema is plotted against the logarithm of length of skull. Open circles indicate individual specimens; the solid circles represent the means of the various samples. Since, as will be discussed below, the slope was found to be similar for each sample, the individual regression lines are considered to be parallel and have been combined into one average line indicating the general trend. The slope and position of the line are calculated by the method of least squares as described by Reeve (1940) or by Snedecor (1946: 318 ff.). The procedures outlined by them are well suited to the analysis since they give not only the regression line but also lead directly to the significance tests mentioned above.

It will be remembered that in equation (1), b is the value of y when x is unity. The same relationship holds in equation (2) in which $\log b$ represents the point where the regression line crosses the $\log y$ axis at which time $\log x$ is equal to zero and x is unity. If calculations were carried out in millimeters, the constant b would thus represent the value of y for a skull length of one millimeter. This seems an unwarranted extrapolation of the growth curve to a very early (or probably non-existent) period of embryonic life. However, if dimensions are expressed in centimeters, b becomes the value of y when the skull is one centimeter in length. This skull size would correspond to a period some time after birth, and if a should be found to be constant from that time on, b would take on more biological significance. A still better unit of measurement might be arrived at if information were available concerning the points during growth where a might possibly change in value; but lacking this, centimeter units are believed to be satisfactory.

Experimental design. An analysis has been carried out on samples from 12 populations representing 12 different areas in Pennsylvania. The collecting localities within each area are given below.

<i>Area</i>	<i>Localities</i>
A.	Erie Co., East Springfield; 4½ mi. SW. of Northeast.
B.	Crawford Co., Linesville; 4 mi. SE. of Linesville; 2 mi. SW. of Linesville.
C.	Warren Co., 2½ mi. N. of Kinzua.
D.	Beaver Co., ½ mi. NW. of New Galilee; 1 mi. NE. of Darlington.
E.	Beaver Co., 2 mi. E. of Industry.
F.	Butler Co., 2 mi. E. of Mars; 3 mi. E. of Mars; 2 mi. W. of Saxonburg.
G.	Fayette Co., 2 mi. NW. of Markleysburg. Somerset Co., 4 mi. SW. of Somerset; 5 mi. WNW. of Salisbury. Westmoreland Co., 4 mi. SE. of Laughlintown; 3 mi. SSE. of Rector; ½ mi. NE. of Rector.
H.	Lycoming Co., 3 mi. SW. of Montgomery; 1½ mi. S. of Nisbet; 2 mi. SE. of Trout Run. Montour Co., 2 mi. WNW. of Danville.

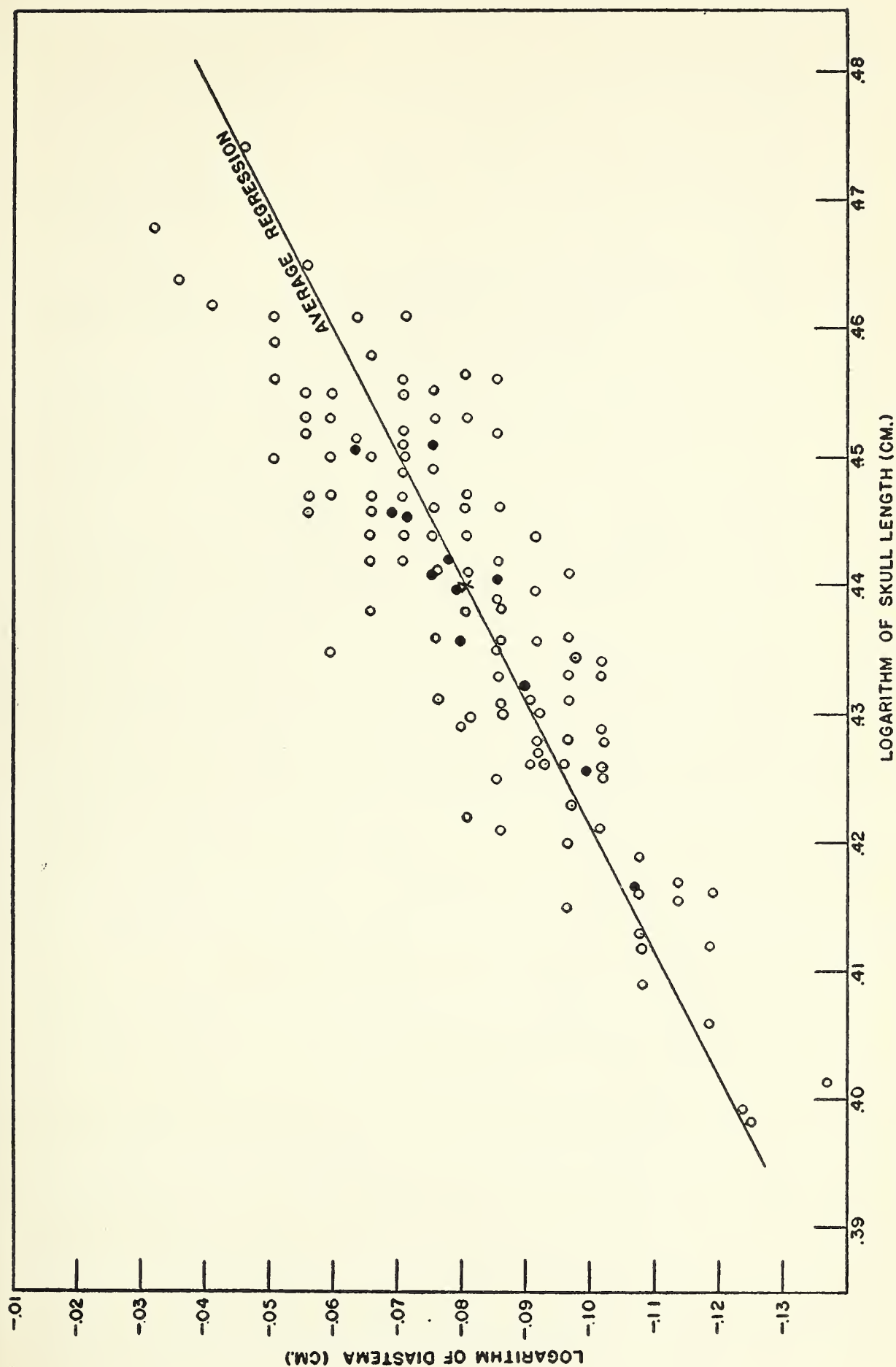


FIG. 6. Regression of logarithm of diastema on logarithm of skull length of male *Microtus p. pennsylvanicus*. Open circles indicate individual specimens; solid circles show sample means; general mean shown by X on the regression line which is an average of the separate lines which could be drawn for the 12 samples plotted.

- Northumberland Co., 1 mi. S. of Montandon; 2½ mi. SW. of Riverside.
- I. Bedford Co., 5 mi. NE. of Chaneyville; 5 mi. ESE. of Chaneyville; 1½ mi. NE. of New Paris.
Fulton Co., Crystal Spring; Fort Littleton; 3 mi. W. of McConnellsburg; 2 mi. E. of Warfordsburg.
Huntingdon Co., 1½ mi. SE. of Orbisonia; 1 mi. NE. of Spruce Creek.
- J. Adams Co., 1 mi. S. of East Berlin.
Cumberland Co., 1 mi. W. of Plainfield.
Franklin Co., 1½ mi. SE. of Fayetteville; 6 mi. NNW. of Chambersburg; 4 mi. E. of Greencastle; 2 mi. NE. of Mont Alto.
York Co., 5 mi. NNE. of Hanover.
- K. Monroe Co., Pocono Lake; 2 mi. NW. of Pocono Lake; 2 mi. NNW. of Pocono Pines; 1½ mi. SSE. of Tannersville.
Pike Co., Bruce Lake; 2 mi. NE. of Bushkill; 5 mi. SE. of Greentown.
- L. York Co., 2½ mi. NE. of Delta; 3 mi. N. of Delta.

These 12 areas represent quite diverse environmental situations both physiographically and biologically. It was mentioned earlier that it would eventually be necessary to know how much this environment affects the characters on which our taxonomic conclusions are based. It would be desirable to know also how much of such environmental influence is exerted directly on each individual and how much has been incorporated by selection into the genetic matrix of each population. These questions, however, are beyond the scope of the present paper. Here it has been necessary to confine the study to determination of the amount and nature of the variation among populations with respect to their spatial arrangement only. Except for the suggestion, pointed out below, that differences in growth constants are likely to reflect genetic differences, the study does not attempt to determine the causes of the variation. A conclusive investigation to determine the relative effects of the various factors which produce the variation remains to be carried out.

Each of the above samples (A-L) contained 11 specimens (males only) primarily of age groups 9 through 12, although in a few cases individuals of age group 8 were included. This was necessary since it was desirable for computational purposes to have specimens complete in all dimensions, and not enough of the older ones were available. This fact also explains why more samples were not included in the analysis and why some samples represent such large areas. There were not enough of the older and intact skulls available to make up more and larger samples. More than seven hundred skulls were examined in order to select the 132 making up these 12 samples. Most of those not used were young specimens; a few were damaged. There were some additional intact adult skulls, but they came from areas where the number of specimens was too few to make up a sample and the locality was too isolated to include within another sample. The age range was restricted as much as possible in order to reduce the chance

of including young specimens the growth of which might be at a different a value. If it were not for this possibility, a greater age spread could be utilized since under a given value of a , similar changes in proportion are considered to have taken place in individuals which have reached the same size even though their ages may be different.

In the case of two skulls which were used in the analysis, one dimension could not be measured because of a broken part. The missing values were calculated from the remaining data and the degrees of freedom reduced accordingly. In these instances the resulting calculated values were quite similar whether obtained by regular regression methods or by the minimum error method of Fisher (1949). The latter is perhaps better for the purpose since it minimizes the errors of estimate of y .

Length of skull was chosen as the independent variable, x .* In an analysis of covariance, seven other dimensions were used successively as the dependent variable, y . One of these, interorbital breadth, showed no significant correlation with skull length within the size range of the samples; and since a separate analysis of variance indicated no significant variation of the absolute size of this dimension throughout the state, further analysis of this measurement was eliminated. Of the other six dimensions three were measurements of length (diastema, rostrum, and incisive foramen), two were measurements of width (cranial breadth and zygomatic breadth), the remaining dimension was cranial height.

The 12 samples were next placed in four groups, with three samples in each group. The areas represented by the samples and the arrangement in groups is shown by the map, Fig. 7. In the analysis, each group was first considered as a sample of 33 individuals and tests were made for differences among groups. Following this, the areas were used as the sample units and differences among areas within each group were tested.

From the foregoing discussion it will be seen that with the design outlined, we can obtain information on two aspects of geographic variation: (1) variability present within small geographic areas in comparison with the amount of variability in relatively much larger areas; (2) amount of variability resulting from differences among populations in growth constants, either the relative growth rate, or the initial growth index. Such variation in growth constants is believed by some workers (Huxley, 1932; Reeve, 1940) to be

*In studies of relative growth with the type of data here available such an independent variable is not justified according to Kavanagh and Richards (1942). This criticism could be overcome by using methods described by Teissier (1948) or by Kermack and Haldane (1950) in which both variables are subject to error. Reeve (1950) has recalculated the growth rate coefficients in anteaters according to Haldane's method; he obtained somewhat higher values than originally, but the differences were not such as to change his interpretations. The disparity in results obtained by the different methods obviously depends on the correlation between the dimensions—the higher the correlation the more nearly alike will be the calculated growth rate coefficients. In the present study the usual method seems to be a valid one since the primary purpose is to predict, for each sample, probable values of the variables for a particular length of skull. However, it should be kept in mind that the constants a and b will not have the same values as if calculated without an independent variable.

evidence for the operation of genetic factors, and for some cases this has been definitely demonstrated (See discussion by deBeer, 1940: 365-393). It is presumed that environmental effects show up mainly in differences in absolute size, to which genetic factors no doubt contribute also. The apparent geographic irregularity in length of skull in such a widely distributed (and supposedly broadly interbreeding) species as *M. pennsylvanicus* might lead one to suspect that environmental factors account for much of the variability in absolute size; but, if hereditary factors are involved, it might be equally argued that genetic mechanisms could cause the same irregularities.

Significance tests. Tests were first made for slope differences by the method described above. Neither the four group regressions nor the 12 area regressions showed any significant variation in slope. Thus, further tests are concerned only with positional differences, and regression lines for individual samples may be considered parallel.

In making the position tests for differences in proportion the method of Reeve, described briefly above, has been extended to take advantage of the hierarchical classification of the samples into groups and then into areas within the groups. Because of this arrangement the data can be combined in several ways in making the tests. Two of these appear to be pertinent here.

Test 1. Deviations from a single line fitted to the 132 individuals are compared with deviations from four parallel lines each representing regression within a group and each based on 33 individuals. If the four lines give a significantly better fit than the single line, differences among the four populations is indicated; and we can assume that geographic variation, involving proportional differences occurs within the state. If the four lines give no better fit than the one, geographic variation in proportions among the four groups has not been established. This test is illustrated by the calculations for diastema in Table 3 and follows the procedure of Snedecor (1946: 320).

Test 2. The pooled deviations from the four parallel lines are compared with the pooled deviations from 12 parallel lines each representing regression within one area and each based on 11 specimens. If the 12 area lines give a better fit than the four group lines, there is variation among the areas within the groups. Further analysis of each group separately (by the method of Test 1) will then determine whether this variation occurs within all groups or only certain ones. The steps involved in Test 2 are again illustrated by the diastema in Table 4. There may be some question as to the validity of this procedure.* I have seen no mathematical treatment in which the data are combined in this fashion in making a covariance analysis; however, the test appears to be a logical one.

*For this particular case, the question is, however, an academic one. The results of Test 1 show that the four lines give no better fit than one line. Thus instead of Test 2 the comparison could actually be made between the 12 parallel lines and one line, and the procedure then becomes similar to Test 1. Such a comparison was made for each dimension and in every case the results were similar to those obtained by Test 2.

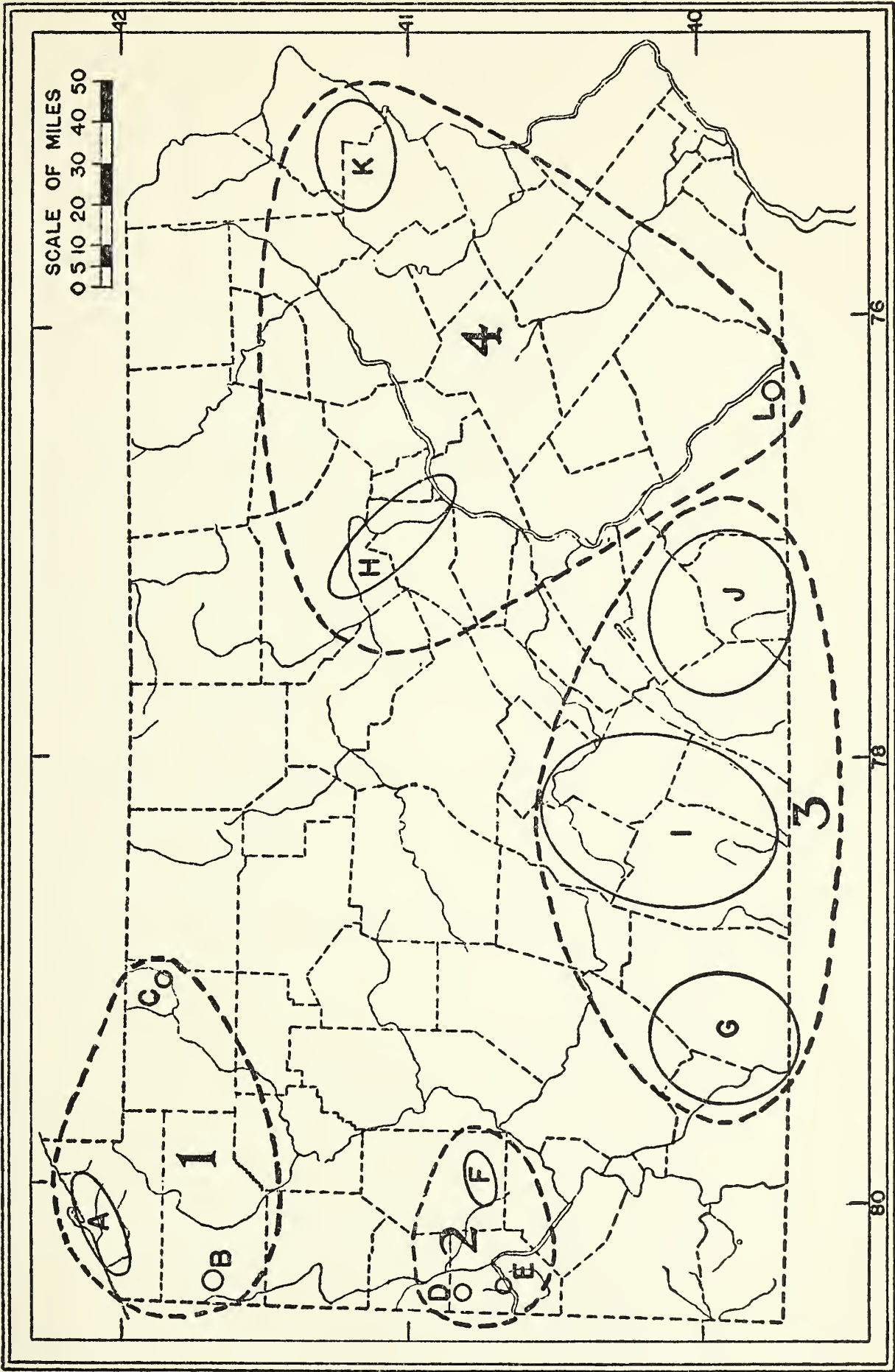


FIG. 7. Areas represented by the samples used in covariance analysis of skull variation in *Microtus p. pennsylvanicus* in Pennsylvania. Groups indicated by 1-4. Areas indicated by A-L.

In addition to the above tests which make use of covariance analysis, we can also make an analysis of variance in which each dimension is tested independently, no regression being involved. The tests are somewhat similar to 1 and 2 above, the difference being that deviations are calculated from the respective means rather than from the regression lines. This latter analysis does not serve as a test for proportional differences; the purpose here is to determine whether differences in absolute size exist. These tests follow the usual variance analysis procedure and need not be illustrated.

Results. The analysis of variance indicates that skull length varies among groups. The means of group 3 and group 4 are the larger, and this may be an indication of a cline in which absolute size increases toward the south and east. There is also variation among areas within groups. A test of each group separately further shows that only in group 2 (areas D, E, and F) are these differences among areas significant. Thus most of the variation in skull length among areas can be traced to this group. Of the other dimensions, cranial breadth, rostral length, and length of diastema exhibit variation among groups; the remaining three do not. However, all except cranial breadth show variation among areas within groups. As in the case of skull length much of this among-area variation can be traced to group 2, but group 1 appears to contribute a considerable amount also. These results from variance analysis for differences in size are shown in Table 5. Columns 3 through 6 give the significance of differences among areas within each group separately; column 7 indicates variation among areas in the combined groups; column 8 gives variation among groups with the areas left out of consideration.

At this point the data indicate that the populations differ in absolute size with possibly a clinal trend. Before drawing any further conclusions it is necessary to carry out the position tests for proportional differences by means of covariance analysis. The results of these tests are perhaps surprising. The size variation among groups can be explained by regression on skull length. In no case do the four group lines give a significantly better fit than one line. Thus, although there are differences in the absolute measurements among the groups, no proportional differences have been demonstrated; but among areas within groups some of the variation in absolute size is independent of variation in skull length. This is true for all dimensions except cranial breadth. Thus proportional differences exist among areas within the groups. It is of interest to note, however, that among samples of group 2, which show the greatest amount of variation among areas in absolute size, but which are separated by a maximum distance of about thirty miles, proportional differences are much less. Almost all the variation in this group is explained by regression on length of skull. Only the incisive foramen, one of the most variable dimensions (See Table 1), shows proportional differences. These results from the analysis for variation in proportion (position differences) are shown in Table 5. As in the case of size differences, columns 3 through 6 are for the separate groups, column 7 gives the results for the combined groups, and column 8 shows

TABLE 3

Comparison of errors of estimate from the best-fitting set of four parallel lines with errors from the best-fitting single line. Regression of diastema length on greatest length of skull in male *Microtus p. pennsylvanicus* from Pennsylvania.

Source of variation	Degrees of freedom	Sums of squares and products			Errors of estimate		
		Σx^2	Σxy	Σy^2	Sum of squares	Degrees of freedom	Mean square
Total	131	0.030107	0.032780	0.047398	0.011708	130	
Among groups	3	0.005292	0.006248	0.007599			
Within groups	128	0.024815	0.026532	0.039799	0.011431	127	0.000090
		Difference			0.000277	3	0.000092

$$F = \frac{0.000092}{0.000090} = 1.02$$

the variation among groups. The calculation for column 7 was illustrated in Table 4; that for column 8 in Table 3.

This situation in which differences in proportion occur locally but not over a wider area poses a logical problem, but its explanation may be simple. It may mean merely that variation in proportion is local and not clinal; the large samples (groups) being heterogeneous would tend to smooth out the differences between the smaller samples (areas). Under this assumption each local population would have, for a given characteristic, its particular range and frequency of phenotypes reflecting in part at least the gene frequencies. If there were a geographic cline, the frequency peaks would not only exhibit local variation but would shift in a regular fashion with distance. This would be evident in a shift of the means from one sample to another along the direction of the cline, especially if each sample included several adjacent local populations. This is what seems to occur in absolute size of skull within Pennsylvania. If there were no cline, the frequency peaks would continue to vary locally but would show no geographic trend. In this case, the means of large samples including several local populations would tend to be the same. The skull proportions appear to vary in this manner. This study does not fit such a model perfectly because some of the samples cover so much geographic area as perhaps to be heterogeneous themselves.

These conclusions do not indicate that large samples covering relatively large areas are not valuable for describing average characteristics of a given species or subspecies. However, they do point to the probability that the local populations are the more basic units. This corroborates what has been evident for some time—that populations differing considerably in absolute size and in proportions may occur within such a small area that formal recognition of them as geographic races or subspecies is neither practical nor desirable. Nevertheless, in studies of wider geographic scope, knowledge of these local variations is very desirable, since clinal trends may be obscured if some of the collecting localities happen to represent extreme local populations. Furthermore, the magnitude of variation between these local populations may approach that occurring between recognized subspecies thus destroying the objective basis of delimitation of these geographic races.

Summarizing these results we may say that variation in size among the populations is produced (1) by variation in factors operating on the skull as a whole thus affecting absolute size, perhaps in a clinal fashion; and (2) by variation in allometric factors which affect proportions within the skull. In the second case no clinal trend is evident within Pennsylvania. In those dimensions where variation in size can be explained by regression on skull length, allometric factors evidently remain constant (for the dimensions involved), and variation in absolute factors alone need be postulated. These factors of size may have a genetic basis, but they could equally well be caused by age, seasonal, or environmental effects. On the other hand, where both absolute and proportional differences occur, allometric factors as well as absolute size factors must differ among the populations. These allometric factors could also be environmental but in the present state of our knowledge they seem to provide a safer indication of hereditary variation

TABLE 4

Comparison of errors of estimate from the best-fitting set of 12 parallel lines with the errors from the best-fitting set of four parallel lines. Regression of diastema length on greatest length of skull in male *Microtus p. pennsylvanicus* from Pennsylvania.

Source of variation	Degrees of freedom	Sums of squares and products			Errors of estimate		
		Σx^2	Σxy	Σy^2	Sum of squares	Degrees of freedom	Mean square
Total	131	0.030107	0.032780	0.047398			
Among areas	11	0.012511	0.014445	0.018851			
Within areas	120	0.017596	0.018335	0.028547	0.009442	119	0.000079
Within groups (from Table 3)	128	0.024815	0.026532	0.039799	0.011431	127	
Difference					0.001989	8	0.000249

$$F = \frac{0.000249}{0.000079} = 3.15^{**}$$

than does the presence of absolute size differences alone. Another advantage of the method used here is that we can take into account such things as slight age differences which we know are present and probably affecting size but which we can not otherwise readily compensate for.

As an aid to interpretation, the means of the skull lengths as well as the means of the other dimensions (adjusted for the differences in skull lengths) are graphed in Fig. 8 for each population sampled. This gives a picture of (1) overall variation in size (as far as this is shown by skull lengths) and (2) variation in other dimensions with the effect of skull length differences removed.

The geographic arrangement is indicated on the graph. In addition, within each of the three sections of Pennsylvania (western, central, and eastern) the samples from left to right represent north to south populations. Thus major trends in either east-west or north-south directions could be detected if present. Study of this figure leads to the same conclusion as we drew from the summary in Table 5, that there are special factors causing proportional variation within the skull; but it is now made more evident that this variation is not particularly clinal or a function of distance, since no obvious trends are recognized.

TABLE 5

Results of significance tests of variation in absolute size (standard type) and in proportion (*italics>*) in the skull of male *Microtus p. pennsylvanicus* in Pennsylvania. *S* indicates significance, and *0* indicates no significance at the 0.05 level of probability.

Dimension	Kind of variation	Among areas within groups					Among groups
		Groups					
		1	2	3	4	All	
1	2	3	4	5	6	7	8
Greatest length of skull	size	0	S	0	0	S	S
Zygomatic breadth	{ size proportion	S S	S 0	0 0	0 0	S S	0 0
Cranial breadth	{ size proportion	0 0	0 0	0 0	0 0	0 0	S 0
Cranial height	{ size proportion	0 0	S 0	0 0	S S	S 0	0 0
Length of diastema	{ size proportion	S S	S 0	0 S	0 0	S S	S 0
Length of rostrum	{ size proportion	S 0	S 0	0 S	0 0	S S	S 0
Length of incisive foramen	{ size proportion	S S	S S	0 0	0 0	S S	0 0

In order to indicate the importance of variation among local populations, samples from other populations of *Microtus pennsylvanicus* in northeastern North America were measured and the means plotted in Fig. 8. As above, skull length is plotted to show variation in absolute size; the other dimensions to show variation in proportion. The samples were allocated to the following subspecies on the basis of Hall and Cockrum (1953): *pennsylvanicus* from Ontario (Peterboro, Kent, and York counties), *fontigenus* from Ontario (mouth of Moose River), and from southeastern Quebec (St. Margaret, Natashquan, and Kegashka rivers), *enixus* from Labrador (Red Bay, Battle Harbor, Windsor, Nain, and the Hamilton River), *labradorius* from Quebec (Nastapoka, Koaksoak, and Great Whale rivers). It is somewhat surprising to find that these populations are quite similar to those in Pennsylvania. Although only relatively small series have been measured, these were (as in the case of the Pennsylvania specimens) selected from a much larger number the great majority of which were immature. The samples should therefore be more representative for our purpose than a larger series containing many younger age groups. It is evident from the graph that with few exceptions the means of the samples of *fontigenus*, *enixus*, and *labradorius* as well as the Ontario *pennsylvanicus* are within the range of the means of the samples from Pennsylvania. The greatest deviation from the Pennsylvania material is shown by the length of diastema in the sample of *enixus*; and in this case the difference is just on the borderline of the commonly accepted level of significance.

It appears that, on the basis of the skull characters used here, samples such as these could not be properly placed with regard to subspecies without a knowledge of the geographic location of the specimens. Since these samples do not constitute topotypical material, no inferences are drawn regarding the validity of the subspecies. Furthermore, other characters could no doubt be found by which these populations could be recognized under prevailing concepts. It may be noted though that Weaver (1940) who had topotypical material of both *pennsylvanicus* and *fontigenus* did not regard the latter as a valid subspecies and referred his specimens from the southern coast of the Labrador peninsula to *pennsylvanicus*. However, the problem presented by these results is not one of finding characters to separate various forms but of arriving at a clear-cut and unambiguous basis for erecting a subspecies. It will probably always be possible to find differences between any two populations; the difficulty is in deciding when the differences are important in relation to the end in view. Perhaps it is time to re-examine the basic concepts by which we continue to describe and recognize mammalian subspecies in order to determine just what is "the end in view." Then we can arrive at some conclusions regarding the purposes and values of infraspecific categories—purposes and values which should benefit the phylogenist as well as the nomenclaturist.

Perhaps the growth constants themselves are of more general interest to biologists than the foregoing remarks which may have little appeal to other than systematists. These constants are given in Table 6. All figures are carried to five decimal places, the maximum number which are significant.

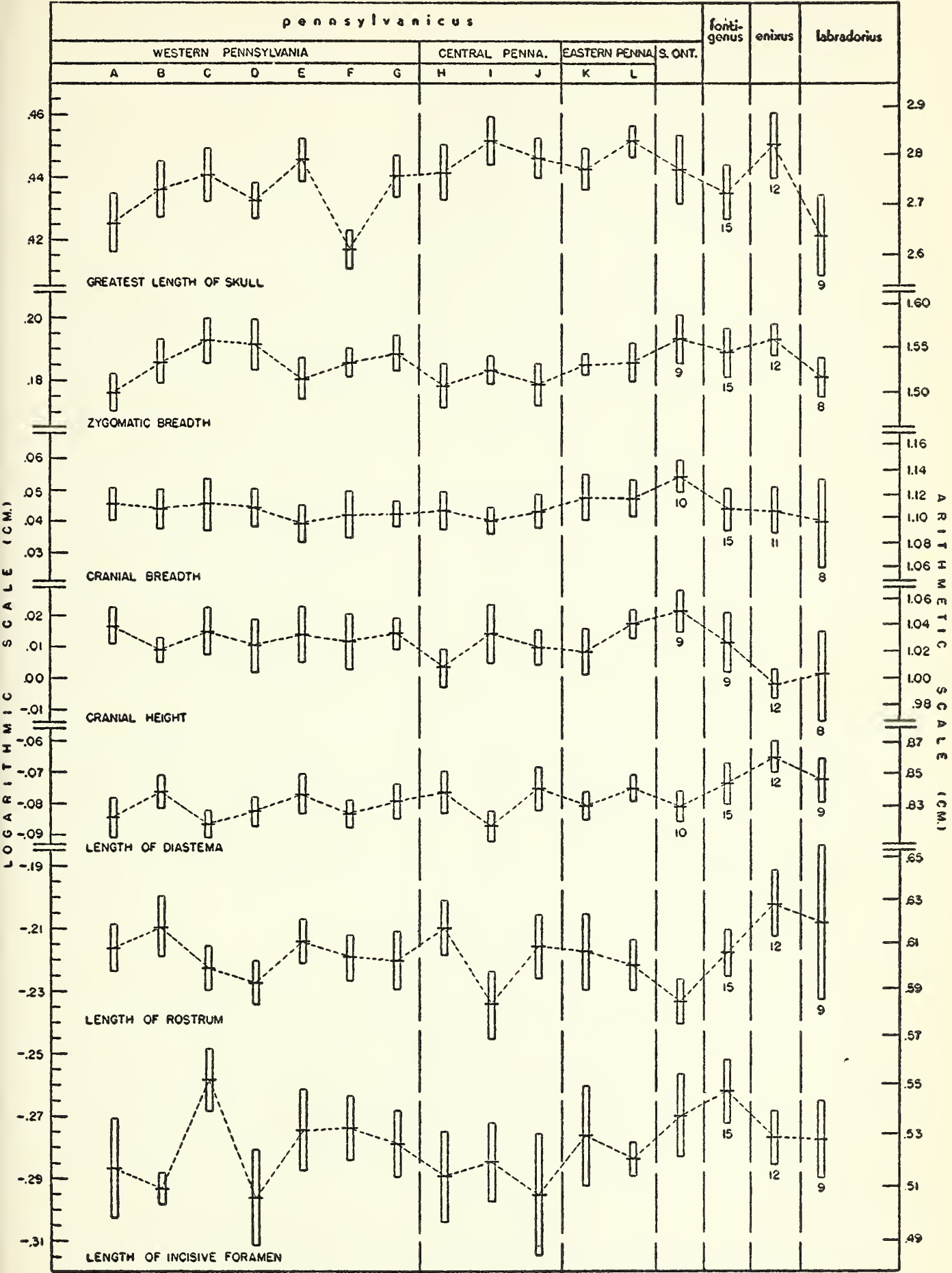
FIG. 8. Variation in skull dimensions of male *Microtus pennsylvanicus* from northeastern North America. The rectangle indicates two standard errors on either side of mean which is represented by the heavy horizontal line. For greatest length of skull the mean is given as computed from the absolute measurements; and the standard errors are estimated by the formula

$$s \bar{x} = \sqrt{\frac{\sum x^2}{n(n-1)}}$$

where x is the deviation of an individual from the mean and n is the number of individuals in the sample. For all other dimensions the means have been adjusted to correspond to a common skull length, in this case the overall mean of the Pennsylvania specimens, 0.43894. The standard errors are estimated by

$$s \bar{y} = \sqrt{\frac{\sum d_{y.x}^2}{n(n-2)}}$$

where $d_{y.x}$ is the deviation of an individual from regression. Each sample contains 11 specimens except where otherwise indicated by number under rectangle.



The values of a are given along with their standard errors. It will be seen that for incisive foramen and diastema the constants are not significantly different from unity. Thus, the regressions of those dimensions on skull length are essentially rectilinear, whereas the other dimensions exhibit a curvilinear regression on skull length since the values of a are, with the possible exception of zygomatic breadth, almost certainly other than unity. It might be noted that allometry is negative for the dimensions of width and height and definitely positive only in the case of rostral length.

As we have already seen, the initial growth indexes are much less stable than the relative growth rates and are of more difficult interpretation, but they are given as $\log b$ in the regression equations in Table 6 for the benefit of any who might wish to compare their results with those reported in this paper. Except for cranial breadth, in which there is no significant difference between means of the samples, $\log b$ in each formula represents an average of the values for the 12 populations. Thus the regression line is an average one and the line for any given population is above or below the average and parallel to it.

TABLE 6

Relative growth rates with their standard errors, and formulas for regression of various dimensions on skull length in male *Microtus p. pennsylvanicus* from Pennsylvania. Value of $\log b$ computed with the units of measurement in centimeters.

Relative growth rate $a \pm s_a$		Regression equation $\log y = \log b + a \log x$
Zygomatic breadth	0.80081 ± 0.07871	$\log y = -0.16771 + 0.80081 \log x$
Cranial breadth	0.36364 ± 0.05703	$\log y = -0.11616 + 0.36364 \log x$
Cranial height	0.61228 ± 0.06586	$\log y = -0.25744 + 0.61228 \log x$
Length of diastema	1.04200 ± 0.06700	$\log y = -0.53887 + 1.04200 \log x$
Length of rostrum	1.41856 ± 0.11182	$\log y = -0.84310 + 1.41856 \log x$
Length of incisive foramen	0.94521 ± 0.16653	$\log y = -0.69847 + 0.94521 \log x$

SUMMARY AND CONCLUSIONS

A series of meadow voles, *Microtus p. pennsylvanicus*, from Pennsylvania was studied to determine the nature and amount of geographic variation with particular reference to the size and proportions of the skull.

The individual specimens were classified in age groups on the basis of relative development of the paroccipital process and of crests in the occipital region of the skull. It was found that the dimensions cranial breadth, cranial height, interorbital breadth, ear, and length of hind foot approach their maximum development at an earlier age than do the other elements considered.

Of the skull dimensions studied, greatest length, condylozygomatic length, cranial breadth, cranial height, and zygomatic breadth show the least individual variation within one population.

An analysis of 150 specimens from several localities in northwestern Pennsylvania indicated that in greatest length of skull males average approximately 0.4 mm. longer than females.

Analysis of variance among samples from seven populations in northwestern Pennsylvania showed that the total variation in all external and skull measurements, except cranial breadth, is significantly greater than might be accounted for by individual variation within each population. Thus, geographic variation in size within this relatively small area is evident.

Analysis, by covariance methods, of the size relationships between skull length and other dimensions showed that within Pennsylvania most of the variation in the skull of *Microtus p. pennsylvanicus* involves factors for proportional differences as well as factors for differences in absolute size. The variation in size shows a slight tendency to be of a clinal nature, but for the most part is quite irregular. The maximum range in size may be shown by populations within one or two counties. Factors of age, season, and environment could be important agents in this variation. Variation in proportion occurs among local populations but exhibits no demonstrable clinal trend within Pennsylvania.

Relative growth rates between the various dimensions and the skull length were found to be similar throughout Pennsylvania.

A comparison of the Pennsylvania material with series from other parts of northeastern North America showed that, for the characters studied, means of samples of *M. p. labradorius*, *M. p. enixus*, and *M. p. fontigenus*, were with few exceptions, not significantly different from, and in most cases actually fell well within, the possible range of mean values of populations of *M. p. pennsylvanicus* from Pennsylvania.

On the basis of the geographic variation observed in this study it is suggested that in systematic studies of wider geographic scope, knowledge of the extent and direction of local variation, both in size and in proportion may be of considerable importance for the correct analysis of clinal trends and recognition of geographic races.

It is further suggested that it would be desirable to re-examine our basic concepts of mammalian subspecies in order to arrive at an unambiguous usage and to clarify the purposes for which they are erected.

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ART. 14. OBSERVATIONS ON MAMMALS ALONG THE EAST COAST
OF HUDSON BAY AND THE INTERIOR OF UNGAVA

By J. KENNETH DOUTT

INTRODUCTION

Clearwater Explorations, Ltd. was organized for the purpose of making geological and biological studies in Ungava. Robert D. Cowen of Cleveland, Ohio, and J. V. Rawson of Plainfield, New Jersey, were responsible for planning and organizing the expedition to Clearwater Lake. Other members of the party were A. T. Wood, Dr. Ray Lawson, George H. Carpenter, William H. Cowen, J. V. (Skip) Rawson, Jr., J. A. Harquail, Bob LaVert, Ted Hunter, Rayburn Reid, Cas X. Gubernat and Dr. J. Kenneth Douth. Without the generous support of Mr. Cowen and Mr. Rawson, the expedition could, of course, never have been undertaken.

I am deeply indebted to Mr. Cowen and Mr. Rawson for the opportunity of visiting Clearwater Lake and Seal Lake during the summer of 1953, and for my participation in one of the most pleasant and most completely equipped expeditions it has ever been my good fortune to join. To the other members of the party, also, I wish to express my appreciation for their most enjoyable companionship.

The first contingent of the party assembled at St. Jovite, Quebec, on July 15, 1953. Two aircraft, a Norseman and a Super Cub, belonging to R. D. Cowen, were loaded there and flown to Clearwater Lake, with stops at Senneterre, Rupert House, Fort George and Great Whale River. We arrived at Clearwater Lake on the afternoon of July 21. A few days later a Canso, or PBY, which flew directly from St. Jovite to Clearwater Lake, brought additional members of the party, as well as supplies and equipment.

Clearwater Lake is one of the large inland lakes of Ungava. The lake lies between 55°50' and 56°20' North latitude and 73°55' and 74°50' West longitude, and at an elevation of about 790 feet above sea-level.

A base camp was made on the northeast shore of the lake at about 56°08' N. and 74°12' W. Here the expedition was divided into four major parties, although there was some overlapping of personnel. Bob Cowen, Bill Cowen, Ray Lawson and George Carpenter, for instance, flew with Rae Reid to Great Whale River to study and photograph Indians and Eskimos, and to make a record of the first native voting. Again, a group consisting of J. V. Rawson, Skip Rawson, Alex Wood, Ray Lawson and two Indian guides, Walter Pachanos and Joseph Shashamish, explored the headwaters of the Leaf River; Ted Hunter and I, with two Indian guides, Thomas George and John Mukash, went to Seal Lake to study the freshwater seal, *Phoca vitulina mellonae*. Jim Harquail, Cas Gubernat and Bob LaVert remained at the base camp, from which, by aircraft, Harquail was able to visit all field parties periodically.

Just as our party was ready to leave for Seal Lake, an expedition from the American Museum of Natural History, in search of the barren-ground grizzly bear, visited us. T. Donald Carter, of the American Museum, and Oshin Agathon, a New York business man, with Tom Watt as pilot and



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Eric Clifford as guide, landed at our camp on Clearwater Lake, then joined us for a few days in our study of the seals in Seal Lake.

Our first camp on Seal Lake was made on August 4, at a rapids where the two main parts of Lower Seal Lake are joined by a narrow channel at approximately $56^{\circ}31'30''$ N. and $73^{\circ}48'$ W. On August 15 we moved camp a few miles northeast, to a deep bay at the end of a long neck of land, $56^{\circ}34'$ N. $73^{\circ}35'$ W. Here we remained until August 21, when we returned to the base camp at Clearwater Lake.

We left Clearwater Lake on August 23, about 10:00 A.M., and arrived at South Porcupine, Ontario, about 7:30 P.M. During the trip our only stops were at Fort George and Rupert House, where we paused long enough to refuel.

Lower Seal Lake is about sixty to eighty miles long and almost as wide. It lies at an elevation of approximately 860 feet. Numerous islands and long peninsulas break it into many long, narrow arms and bays. Upper Seal Lake lies about twenty to thirty miles to the south and is connected to Lower Seal Lake by a series of small lakes and rivers. To the Indians, Upper Seal Lake is known as "Menasqua ashuguanipe," which means "Seal Lake in the Woods," and Lower Seal Lake is known as "Mushawa ashuguanipe," meaning "Seal Lake in the Barrens." As is indicated by the Indian name, Lower Seal Lake is at the edge of the barrens where the trees become stunted or entirely disappear. Black spruce, white spruce and tamarack are common trees in protected ravines and valleys, but they never become very large. The largest one we saw was a tamarack 42 feet high and 11 inches in diameter, two feet above the ground. The tops of the hills and the exposed slopes are covered with lichens. Other low species, such as blueberry and crowberry, creep along the surface of the ground. In the wetter areas, which have some protection, sphagnum moss, bake-apple and Labrador tea are common species.

The land is so dotted with lakes that at times one gets the impression that there is more water than land. Low, rounded hills, with an occasional vertical cliff, rise a few hundred feet above the level of the lakes, and everywhere the hills are covered with an abundance of boulders of all sizes, scattered promiscuously by the glaciers. Long, narrow eskers wind their way across country and at times make excellent pathways where, otherwise, walking would be difficult. Sometimes caribou trails follow the ridges of these natural embankments.

The temperature in the summer of 1953, seldom rose above the upper sixties or low seventies during the day, and at night often dropped to the upper thirties. Rain, fog and high winds were common; in fact, we had either high winds, rain or fog—or a combination of these—about two-thirds of the time. Weather is the factor which, more than any other one thing, determines the amount of seal hunting one can do in this country. During the 17 days we spent on Seal Lake, only three days were really good for seal hunting, and parts of three others were fair to good. For the rest of the time there was little chance of finding seals because of the cold, cloudy weather and rough water. However, we traveled about the lake, examining

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the hauling grounds and watching for places where the seals might be feeding.

Mosquitoes and black flies were both abundant. While the black flies work only the day shift, the days are eighteen to twenty hours long during July and August. The mosquitoes know no shifts, but work around the clock. Fortunately, cold, rainy weather, with high winds drives them all into hiding, and so one comes, at times, to regard the miserable weather as a blessed relief. Fortunately the modern repellents are working wonders against this really great scourge of the north country.

Although the major objective of my part in the expedition, and the one which occupied most of my time, was a study of the seals, I made an effort to obtain information and to collect other specimens as time and opportunity permitted. During the 25 days in which collecting equipment was available I collected a total of 87 specimens. Representatives of the mammals which were collected are to be deposited in the Royal Ontario Museum of Zoology, at Toronto, Ontario, Canada. The information obtained is presented in this paper. A list of the plants collected will be presented in a separate publication.

The Cree Indian names presented here are my own phonetic renderings of the words the Indians gave me.

MAMMALS COLLECTED, OBSERVED OR NOTED

Sorex cinereus cinereus Kerr. Common cinereous shrew. Cree name "Chin-stu-oy Avook-shish."

Two specimens were trapped by T. Donald Carter at Camp One, Lower Seal Lake.

Ursus americanus Pallas. Black bear. Cree name "Cha-ouk."

The Indians told me that the black bear is sometimes found as far north as Richmond Gulf. Thomas George told me that he killed three on a lake at the headwaters of Little Whale River (southwest of Clearwater Lake) last winter (1952).

Ursus maritimus Phipps. Polar bear. Cree name "Wab-sque" or "Wab-sk."

A female and cub were obtained by Mr. Cowen at Great Whale River, August 9, 1953. Although Carnegie Museum has specimens taken farther south, from the Twin Islands and Walter Island, as recently as 1935 and 1938, the natives reported to Mr. Cowen that it was the first time in the memory of any living residents at Great Whale River Post that polar bears have been known to come ashore there. This unusual occurrence might, in part, be attributed to the fact that the pack ice remained in this section of the bay until almost the middle of August in 1953.

Ursus sp. Grizzly bear.

I have nothing but hearsay evidence for listing this species. However, stories about a bear, which is neither a black bear nor a polar bear, are so current in this region that they deserve more than casual attention. The descriptions are accurate enough to suggest a grizzly bear. In one case, my informant had seen the skin of a strange bear, but he had seen it many

years ago. This past summer, Oshin Agathon and T. Donald Carter of the American Museum of Natural History, New York, conducted an expedition into this region looking for this bear. Unfortunately, they found nothing either to substantiate or discredit the reports.

Martes americana brumalis (Bangs) Marten. Cree name "Wab-stan."

Although I saw no specimens of marten this year, the Indians told me that they had taken it on Upper Seal Lake. I understood them to imply that this was its northern limit.

Mustela erminea richardsonii Bonaparte. Short-tailed weasel. Cree name "Shuk-sch."

A small carnivore living among the broken rock piles ate mice which were caught in my traps. It was not seen, but I suspect that it was this species. The Indians knew it well. However, it may have been the following species which did the damage.

Mustela rixosa rixosa (Bangs). Least weasel.

No specimens of *rixosa* were taken this summer, but I have collected specimens of it at Great Whale River, and Kogaluk River (approximately 59°54' N., and 76°40' W).

The two specimens from Kogaluk River are somewhat larger than the two specimens from Great Whale River and another specimen from an island south of Comb Hills, James Bay. However, they are well within the limits of size which Hall (1951) gives for *Mustela rixosa rixosa* from Saskatchewan.

Hall points out that the eight specimens he had from eastern Canada show differences which might justify the naming of a separate race, but these two specimens from Kogaluk River seem to complicate the picture rather than simplify it. Furthermore, I have a specimen of *Mustela rixosa allegheniensis* from Pittsburgh which virtually duplicates all of the measurements of the male from Kogaluk River! The brown spots on the breast, which Hall considers, are no help, for the female from Kogaluk River has a series of small ones on her breast, but the male has none. Of the two females from Great Whale River one has a large brown spot, the other has a small spot in the center of the abdomen. The female from south of Comb Hills has no spots. Until a greater series of specimens can be assembled, which will show the characters more clearly, it seems best to refer these specimens to the subspecies *rixosa*.

Gulo luscus luscus (Linnaeus). Wolverine. Cree name "Que-quad-jou."

Although the animal was well known to the Indians, they had not seen any in recent years.

Lutra canadensis chimo Anderson. Ungava land otter. Cree name "Ne-jook."

In the northwest arm of Seal Lake we found three otters playing, not more than 200 yards from the spot where I killed one in 1938. One of these was collected for a specimen. I have collected specimens on other expeditions, as far north as the headwaters of the Povungnituk River.

Mephitis mephitis mephitis (Schreber). Striped skunk. Cree name "She-kak."

When shown a picture of this animal the Indians recognized it at once. They said it did not occur in this region. The farthest north they knew of it occurring was Rupert House in southern James Bay.

Vulpes fulva bangsi Merriam. Labrador red fox.

Although none of our party saw a fox this summer, the animal must have been abundant, because the sandy beaches, wherever we went, were covered with fox tracks. I found three fresh burrows in the sandy bank of Long Point; at another place I found the remains of a *Clethrionomys* which a fox had killed and partly eaten, and we found tracks where foxes had been stalking geese. Unfortunately, we had no fox traps with us.

Alopex lagopus ungava (Merriam). Ungava Arctic fox. Cree name "Wabakashu."

The Indians said that this species occurs in the vicinity of Seal Lake too, but we saw none this summer.

Canis lupus labradorius Goldman. Labrador wolf. Cree name "Me-hee-kan."

The Indians knew the wolf, but said they seldom see one. They said its principal food is caribou.

Lynx canadensis canadensis Kerr. Canada lynx. Cree name "Bi-shu" or "Pe-shu."

The Indians indicated that it occurs in the vicinity of Ft. George, but not at Seal Lake.

Phoca vitulina mellonae Doult. Ungava freshwater seal. Cree name "At-chook" or "At-chuk."

Although landlocked seals have been known for many years from Europe and Asia, until recently none had ever been described from North America. When I first visited Hudson Bay in 1935 I made specific inquiry about landlocked seals which had been reported from Lake Minto. I was told, by the Eskimo Kooke, that seals did not occur in Lake Minto, but that there were landlocked seals in Seal Lake. It was impossible to go to Seal Lake that year, but I determined to return at a later date to investigate the report. Consequently I planned, as one of the major objectives of the 1938 Carnegie Museum Expedition to Hudson Bay, to visit Seal Lake. At Great Whale River a party of Cree Indians was engaged to help transport the equipment and supplies, and during February and March we walked into Seal Lake on snow-shoes. (See Doult, 1942, p. 61-125.) On this expedition I learned that the lakes of Ungava freeze to a depth of several feet. During the trip we frequently had to cut down through three feet or more of ice to reach the water of the lake. It is obvious that the seals living in any of these lakes have to congregate at places where rapids or low falls keep the water from freezing, for unlike *Phoca hispida*, (the ringed seal), which is the common species along the east coast of Hudson Bay, these seals do not keep a series of breathing holes open through the ice. Thus they are dependent upon open water for air. During the summer the seals crawl out on shore only on bright, sunny days, to sleep and sun themselves; but when the weather is cloudy or a cold wind is blowing, they remain in the water.

Although seals may be found anywhere in Seal Lake, during the summer there are certain places where they are most likely to occur. Swift water, or a low rapid, is usually a good spot to look for seals, because they go to such places to feed. Little bays, which are protected from the wind, are ideal, for it is in such places that they most commonly climb out on shore to sleep or sun themselves. The water in these bays is often quite shallow. One, which we examined on August 13, is typical of many. We left our canoes on the shore of the main part of the lake. There was nothing to indicate the presence of such a bay, but Thomas George knew the place and led the way across a narrow neck of land, perhaps 200 yards wide. As we neared the water on the other side he indicated that we should be very quiet. A seal's eyesight is keen, its sense of smell acute, and when it is out of the water it is very cautious; thus, when looking for seals on shore one must approach their hauling grounds with great care. From the top of the ridge, which was perhaps twenty feet above the water, we examined the opposite shore. Finding nothing, we went closer so that we could see the shore line nearest us, then proceeded up into the head of the bay. At one spot the water was very shallow and we were able to cross on stepping stones. Here we found the long, narrow trail which a seal had made as it inched itself along over the mud. As we went into the farther part of the bay, the water became deep again. All along the shore of this bay we found places where the seals had crawled out. On the rocks there was only slight evidence of wear, where the lichens had been rubbed away. On the grassy spots, of course, the evidence of the seal beds was very clear. The grass and sedges had been padded down from the weight of the heavy bodies. In this one small bay (it was not more than 300 yards long and 50 yards wide), we found at least a half dozen old beds; some looked as if they had been used not more than three or four days before. We examined eight or ten such bays during our hunting on the lake.

On the other hand, we found places where the rocks dipped steeply into the water. Along this type of shore the seals also haul out to sleep, on low, rocky ledges. One such place which we examined on August 9 was typical. On this occasion, Thomas George and I went alone. We took the outboard motor to facilitate our return to camp, but on the way out we used only the paddles. About three or four miles east of camp a long, narrow, sandy point extended eastward into the lake for two miles or more. Thomas knew a portage point across it and we headed for that. The seals evidently knew and used this same portage, for when we got there we could see tracks in the sand where a seal had crawled across. It was only about ten feet from one shore to the other, and only a foot or two above water level. Thus, it was an easy passage from one part of the lake to the other, and saved several miles of paddling—or swimming—as the case might be. With binoculars and telescope we searched the rocky shore on the opposite side of the bay, but seeing no seals we paddled on, following the contour of the shore. As we rounded each point we stopped to examine the shore ahead for seals. In about a mile we came to another portage. This was even shorter than the last. It was not more than four to six feet wide and only a foot or less

above the water—just a narrow groove in the solid rock. We slid our canoe through it, then climbed a low hill to examine the bay ahead. Thomas showed me where he had killed a seal a few years ago, and told me about a place where Jacob Rupert and another Indian had killed nine seals at one time. The bay here was surrounded by rocky hills which dipped steeply into the water. Rocky ledges, projecting slightly above the water level, made ideal places for seals to sun themselves. The hills offered protection from the wind, but that day the sun did not shine and we found no seals. In another mile or so we came out into a wide part of the lake. Here the wind had a clear sweep and was blowing up small white-caps, so we knew there was no use looking for seals on the rocks. We continued on northwestward, however, to a place where the lake narrowed down to a river, and a strong current flowed to the southeast. We spent some time on a small island, hoping to find seals feeding in the rapids. The seals live on fish and will take only live ones, the Indians say, so there was no point in trying to bait them with dead fish. We had three seal nets with us. Two were made like a purse. If the seal swam into it, the net would pull shut and the seal would be in a bag. The other net was similar to a gill net for fish, but made of much heavier twine. In this net the seal supposedly becomes entangled and so wrapped up that it can not get out.

On days when the weather was not very good for seal hunting, we would paddle along the lee shore to a small bay where, because of the protection afforded by the surrounding ridges, the water was relatively calm. On a projecting point at the mouth of the bay we would go ashore, haul up our canoe and build a fire. Our trip to Kouk Island on August 17 was typical of this type of hunting. Although the weather was not good, there was a chance it might improve, so the two Indians (Thomas George and John Mukash) and I packed lunches and left camp about 7:00 A.M. We paddled northeast along the lee shore for several miles. About 10:00 A.M. we came to a point of land on the south side of a long, narrow bay. The bay was well protected from the wind, and the water was calm enough to see the head if a seal came to the surface to breathe. We went ashore and hauled our canoe up on the beach. John built a big fire and after it was well started he proceeded to throw green branches on it. He explained that the smoke would drift out across the lake and if a seal smelled it, it would come over to see what was causing the smoke. He also threw large stones into the water, in order to make a big splash. He said this, too, worked on the seals' curiosity and would bring them into the bay where we could see them. As the morning wore on, the wind increased and rain began to fall. We piled our food, camera bags and other equipment under a large rock; John cut off some of the lower branches of a dense spruce tree which was growing close to the fire, so that we could crawl back under the tree and avoid some of the rain. One of us kept watch for seals in the calm waters close to shore, while the other two dried out by the fire. We had our lunch, but as the day wore on, the weather got worse. I had visions of being weather-bound for a day or so, and without food or camping equipment the prospects were not inviting. All the smoke and rocks failed to entice any seals, so about 3:00 P.M. we decided to start back for camp. Except for some very rough

weather, our trip was uneventful until we got into the bay where our camp was located. About half way down the bay Thomas had a glimpse of a seal's head as it appeared for a moment above the water. In a few minutes the seal appeared again, but only for an instant, and was gone before we could shoot. We waited and hunted back and forth along the beach for an hour or more, but never saw it again. It seemed ironical that we should go so far from camp, through the bad weather, and then have a seal come almost into camp.

The next fine day we went to the northeast end of the lake, to the region where we killed our seals in 1938. Tom and I went up to a little falls, while John watched for seals at the fast water. Although it was a perfect day and we traveled about thirty miles, most of it paddling quietly along shore, we saw no seals.

We spent 17 days on Seal Lake. Of this time, only three days were really good for hunting seals; parts of several other days were fair, but most of the days were cold, cloudy, windy and often rainy. In all of this time, we saw seals on only four or five occasions, and it is possible that only one or two individuals were involved. It would seem that seals in Seal Lake were not very abundant this summer. There may be some fluctuation in the population from year to year or, perhaps, over longer periods of time.

Odobenus rosmarus (Linnaeus). Atlantic walrus. Cree name "We-bu-jo" or "We-bet-cheu."

Although the Indians know the walrus they seldom—almost never—hunt it. This is principally because the walrus does not come close to the mainland. While the Indians are expert canoemen, they seldom venture far out into Hudson Bay. The Eskimos, particularly at Port Harrison and Povungnituk, however, have Peterhead boats and annually organize walrus hunts to the off-shore islands. To the Eskimo, the walrus is a valuable source of dog food. The tusks furnish ivory, which is also important to them, for it is used in the construction of many of their implements, such as seal spears and kayak paddles. Handles for many objects, such as knives and dog whips, as well as dress ornaments, combs, trinkets and many carvings, are also made of ivory. The importance of the ivory to the Eskimo may be indicated by the fact that the word "Ivik," which is their word for ivory, is the same as their word for walrus.

Tamiasciurus hudsonicus ungavensis Anderson. Ungava red squirrel. Cree name "Nu-goo-jash."

Our Indians were familiar with the red squirrel, one of which lived in the stunted black spruce trees behind our camp at Clearwater Lake. I often watched it eating seeds from the cones of the black spruce. Strangely enough, I saw no sign of this species at Lower Seal Lake.

Glaucomys sabrinus makkovikensis Sornborger. Labrador flying squirrel. Cree name "Ke-shá-lu."

I have examined specimens of the large northern flying squirrel from the vicinity of Ft. George and Rupert House, and I suspect that it ranges widely through the interior of Ungava, around the headwaters of the Ft. George, East Main and Rupert rivers. Specimens from this side of the peninsula

differ slightly from those in the Atlantic watershed. The back is buffy brown instead of rusty, the tail is lighter, and the belly is more heavily washed with buffy brown. In the specimens I have at hand, these characters seem to be relatively constant and I first considered describing them as a new subspecies. Further consideration of this problem, however, caused me to abandon this idea, at least until a more thorough study can be made of the relationships between specimens from the east and west sides of the Ungava Peninsula. The specimens I have from Ft. George were probably brought down from well back in the interior by Indian trappers. They were given to me in 1935 by William Watt, who was then Manager of the Ft. George Post of the Hudson's Bay Company. He told me that flying squirrels were relatively scarce and that he got about one of them to every 200 red squirrels. J. S. Watt, who was Manager of the Hudson's Bay Company Post at Rupert House for many years, also told me that flying squirrels were rare.

I have also examined a series of specimens from the Hamilton River drainage, which I obtained through the courtesy of T. E. Keats, who was Manager of the Hudson's Bay Company Post at Northwest River in 1939. One of these specimens was very dark, almost black. A series of *Clethrionomys* from the Hamilton River area also contained some individuals which were almost black. It may be possible that there is a tendency toward melanism in mammals in this area.

Castor canadensis labradorensis Bailey and Douth. Labrador beaver. Cree name "Am-insk."

John Mukash killed six beaver at Clearwater Lake in the past year or so. This must be near the northern limit of this genus on the west side of the Ungava Peninsula.

Synaptomys borealis innuitus (True). Ungava lemming mouse. Cree name "Avook-shish."

The Indians did not seem to distinguish this species from the Meadow Mouse, *Microtus*, or *Phenacomys*; at least they used the same name for all three. I trapped only two specimens at Seal Lake. They were not nearly so common as *Phenacomys* or *Clethrionomys*.

Two races of *Synaptomys* have been described from Ungava—*Synaptomys borealis innuitus*, with type locality at Fort Chimo on the northern end of the Ungava Peninsula, and *Synaptomys borealis medioximus*, with type locality at L'Anse au Loup, Strait of Belle Isle on the southern margin of the peninsula. Our specimens from Seal Lake are much closer, geographically, to Fort Chimo and on this basis I have assigned them to this subspecies. I have, for comparison, one specimen without skull from Fort Chimo and one specimen from Red Bay, Labrador. Our specimens are markedly different from either and may possibly represent another race from the western side of the peninsula. Further study of this problem is indicated.

Dicrostonyx hudsonius (Pallas). Labrador lemming. Cree name "Che-mavook-shoo."

Although I searched for lemmings at Seal Lake I found no evidence of

their presence this year. I was familiar with them at Povungnituk and Great Whale River. Both places are more strictly arctic in nature than is Seal Lake. Our southernmost record is from Kakachischuan Point, at about 50° N. latitude. This is on the east coast of James Bay and is about fifty miles south of Cape Jones. Because of its proximity to the cold waters of Hudson Bay this place is in the arctic life zone, although the Canadian zone begins a mile or so inland.

Phenacomys ungava ungava Merriam. Ungava *Phenacomys*. Cree name "Avook-shish."

The Indians did not distinguish between this species of mouse and other similar kinds, such as *Microtus* and *Clethrionomys*. I trapped 20 specimens at Seal Lake and Clearwater Lake. These specimens are larger than specimens from Fort Chimo. This difference in size, and differences in color and skull characters, seem to indicate that specimens from this area may represent a new race. Further study of this problem is desirable.

Clethrionomys gapperi hudsonius Anderson. Hudsonian red-backed mouse. Cree name "Avook-shish."

This was the most abundant small mammal in the vicinity of Seal Lake in the summer of 1953. It outnumbered, by three to one, all other species I caught in my traps. That they were serving as food for the foxes was indicated by tracks on the sandy beaches and by the remains of one which a fox had left only partly eaten.

At our first camp on Lower Seal Lake, *Clethrionomys*, *Phenacomys* and *Synaptomys* were all taken in the same runways. They lived among the large blocks of rock, which formed excellent protection. These large rocks also formed shelter for the plants which grew near them. Such plants as twin flower, crowberry, ground-pine, ledum, blueberry, and dwarf dogwood were common. Since all three species of mice were using the same runways, it was not possible to tell which species was responsible for cutting the plants, but I found leaves of the dwarf dogwood, a berry of the crowberry, and parts of branches of the ground-pine carried into the runways. I also found large piles of droppings in some places, indicating that these mice have preferred spots for such purposes. Some of these piles contained a double handful or so of pellets and had probably accumulated under the snow during the winter. In other places the piles were still being used.

Microtus pennsylvanicus labradorius Bailey. Ungava meadow mouse. Cree name "Avook-shish."

Although considerable trapping was done at Clearwater Lake and Seal Lake this summer, no specimens of *Microtus* were taken. I was somewhat surprised to find them absent here, for in other years I had found them relatively common along the coast as far north as Povungnituk.

Ondatra zibethica aquilonia (Bangs). Labrador muskrat. Cree name "Oot-shk."

Although we collected no specimens of muskrats at Clearwater Lake or Seal Lake in 1953, the species is well known to the Indians who live in this region. On former expeditions I have collected specimens at Great Whale

River and at Kikkerteluk River, latitude 58° N., longitude 77°10' W. along the east coast of Hudson Bay.

Erethizon dorsatum picinum Bangs. Labrador porcupine. Cree name "Ko-uk."

No porcupines were collected in 1953, but the Indian name for one of the islands in Lower Seal Lake is "Kouk-one-nook." When I asked the Indians why it was so called they told me that it was because porcupines at one time inhabited the island. Thomas told me that last year, on an island just east of our second camp, he saw two trees the bark of which had been eaten off by porcupines although he did not see the animals. He also told me that James Mammiamskum, an Indian at Great Whale River, had the skull of one which he had killed near Richmond Gulf.

Lepus arcticus labradorius Miller. Hudson Bay Arctic hare. Cree name "Mis-tou-ks."

Although the Indians were familiar with the Arctic hare, we saw no sign of it at Clearwater Lake or Seal Lake. I have collected specimens of them on the Manitounik Islands just north of the mouth of Great Whale River and Carnegie Museum also has specimens from ten miles north of Great Whale River and from Richmond Gulf. Evidently Great Whale River is near their southern limit on this side of the bay.

Lepus americanus americanus Erxleben. American varying hare. Cree name "Wa-bush."

We did not see any rabbits in 1953, but at a few places around Seal Lake we saw tracks and droppings.

Rangifer caboti G. M. Allen. Ungava caribou. Cree name "A-took."

Since my first visit to the east Coast of Hudson Bay in the summer of 1935 I have been trying to assemble data on the status of the caribou. During the early part of the last century they were extremely abundant over much of Ungava. About the turn of the century, however, they suddenly vanished, and many Indians and Eskimos starved to death.

Many suggestions have been offered to explain the disappearance of the caribou, but no one knows what actually did happen to them. To my mind, the most probable cause was the rapid spread of some new disease or parasite. Whatever the cause of their decimation may have been, it is certainly true that caribou were extremely rare in Ungava during the early part of the twentieth century.

When I first visited Seal Lake, in 1938, I was looking for landlocked seals and did not have time to hunt for caribou. However, in the course of our traveling through the interior, I saw tracks of several caribou in the region between Clearwater Lake and Lower Seal Lake. James Sandy, one of our Indian guides, told me that a small band of caribou then lived in the region between Lake Minto and Lower Seal Lake during the winter, and that in the summer they traveled through the country between Lower Seal Lake and Upper Seal Lake. He said there were about thirty to forty caribou in the herd. James Sandy told me that he had killed 10 caribou between Clearwater Lake and Upper Seal Lake during the summer of 1934.

I spent the spring and summer of 1945 in the vicinity of Povungnituk, and during April and May I traveled inland by dog-sled with a party of four Eskimos. During this trip I saw several bands of twenty or more caribou and the tracks of many others. Sam Ford, who was manager of the Hudson's Bay Company Post at Povungnituk, told me that the Eskimos in that area had killed about two hundred caribou during the fall and winter of 1944-1945. From all the reports that I could gather, a similar number had been killed by the natives who lived in the vicinity of Port Harrison.

During this past summer we covered, by aircraft, more than one thousand miles, from Great Whale River to Clearwater Lake, Port Harrison and Fort George. We also did a considerable amount of flying in the area between Clearwater Lake and Seal Lake. Although we kept close watch for caribou during these flights, and frequently followed their trails for several miles, we saw none. The difficulty of locating, from aircraft, parties lost in the bush is well known. However, this country is semi-barren. The spruce and tamarack are stunted and grow only in protected places. The tops of the hills are customarily bare, except for caribou moss and other low-growing plants, so that one gets the impression that it would be very easy to see any animals that were within several miles of the line of flight. While vision is unimpeded, this confidence of being able to see objects on the ground, while flying at 500 or 1000 feet, is a delusion which leads to many false assumptions. This was well illustrated by an incident that took place the day we moved camp on Seal Lake. The Cub, which cruises at only about ninety miles per hour, landed at our old camp, and Ted Hunter told Cas Gubernat, the pilot, approximately where we had gone to set up our new camp. Cas and Jim Harquail flew directly over us at an altitude of about five hundred feet. We were, at the time, on an open tract of ground. Our canoe was on a clear, sandy beach, and when we heard the aircraft coming we ran to the top of the nearest hill and waved a piece of white canvas to attract their attention. Ten minutes or so later, when the Cub returned, we had a fire built on the beach to make a smoke. We waved the white canvas as well as our arms and hats. Although they flew almost over us again, they did not see us either time. I think this illustrates very well how easy it is to overlook an object on the ground, although from a seat in an aircraft, one is confident of being able to see every object below. With this in mind, it is easy to understand that we may have flown over caribou without seeing them.

The moment we went ashore at Seal Lake we saw fresh tracks of caribou on the sandy beach, and during the 17 days we spent at Lower Seal Lake we saw tracks of five or six more. The tracks of one were seen along the shore where we made our first camp. The Indians found very fresh tracks a day or two later, and were so sure that they could get the animal which made them that they left early the following morning, after making preparations for bringing it back to camp. However, the caribou had moved on in the meantime and they did not get it. I found the bones of several which had been killed the previous winter. Thomas George told me that two of

them were ones which he had killed. A well-worn caribou trail ran along the shore just behind our camp. Relatively fresh pellets in it indicated that it had been used by caribou that spring. When we moved to our second camp on Seal Lake we also found fresh tracks, as well as places where the caribou had been grazing on the lichens. I asked Thomas George how many caribou he had killed in his lifetime here (he was then about forty-five years old). He could not begin to tell me the number—all he could say was, "many, very many."

From all the evidence which it has been possible for me to accumulate over the past 18 years, it seems that the number of caribou is gradually increasing in this vicinity. If reasonable protection can be given to them, by preventing white men from killing them, I believe they will, in time, build up again to good-sized herds. There is an abundance of food. We saw no evidence of the destructive fires mentioned by Manning (1946, p. 82-83), which occurred at the head of Moisie River and at Lake Nichikun. Wolves are very scarce, and there are no other large carnivores which could be serious predators.

I have heard suggestions that reindeer be introduced into this area to supplement the caribou. This, I think, would be a grave error and might lead to most disastrous results for the native caribou. It is possible that the reindeer might bring into the region parasites or diseases which would be very harmful to the caribou. Furthermore, there is no assurance that the reindeer would do any better in this region than the caribou has. The experiment of introducing reindeer into Alaska, was, unhappily, not very satisfactory nor successful. The reindeer is inferior in size, and is not as desirable an animal as the native caribou. It would be much cheaper, for the present, to provide the population of Eskimos and Indians with the necessary number of caribou or reindeer skins imported from other areas, than to try to establish herds of reindeer in Ungava. This would give the native caribou a chance to re-establish itself. Summing up all the information I have, it seems to me that there is as much reason to believe that the caribou will again establish itself, if given protection for a period of time, as there is to believe that the reindeer could be established to advantage. Furthermore, the chances of doing serious damage to the native fauna of Ungava by introducing a foreign species, with its attendant retinue of diseases and parasites, is so great, and the chances of this introduction succeeding to the benefit of the native Eskimos and Indians are so slight, that no attempt of this kind should be made without a thorough study of all phases of the problem. Even then, if it is decided to try to introduce reindeer or any other foreign species, the experiment should first be tried on some island, such as Mansel, Coates or Southampton. If the experiment did not prove to be satisfactory there, the whole mainland of Ungava would not be polluted by new disease organisms and parasites.

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ART. 15. THE GROUND SNAKE, *HALDEA VALERIAE*, IN
PENNSYLVANIA AND WEST VIRGINIA WITH DESCRIPTION OF
NEW SUBSPECIES*

BY NEIL D. RICHMOND

INTRODUCTION

When Blanchard revised the genus *Virginia* (*Haldea*) in 1923, no specimens were available from either Pennsylvania or West Virginia. In 1936 Conant reported finding *Virginia valeriae valeriae* in eastern Pennsylvania. In 1947 Swanson listed eight counties in Pennsylvania in which *Haldea valeriae valeriae* had been taken. Cooper (1948) reported finding a specimen of *Haldea valeriae valeriae* in Garrett County, Maryland. It was first reported from West Virginia in 1950 by Wilson and Friddle. In 1953, in the course of field work of the Pennsylvania Herpetological Survey, 15 additional specimens of this secretive form were collected, and four of the females conveniently produced broods in the laboratory, adding 25 juveniles. These, with occasional specimens collected in recent years, have provided 60 specimens from Pennsylvania and 6 from West Virginia, 30 more than Blanchard had available in 1923 from the entire range of *valeriae*.

Examination of this material disclosed two forms, one of which has not previously been recognized. The specimens from eastern Pennsylvania and from West Virginia are referable to *Haldea valeriae valeriae*. Those from the Appalachian Plateau of western Pennsylvania differ from both *valeriae* and *elegans* and are here described as a new subspecies of *valeriae*.

DESCRIPTION

Haldea valeriae pulchra subsp nov.

Mountain ground snake

Diagnosis. A form of *Haldea valeriae* with keeled scales in 15-17-17 rows. In the other two forms known, *elegans* has scales in 17-17-17 rows, usually more or less keeled, and *valeriae* has scales in 15-15-15 rows, usually smooth, rarely with a few keeled scales posteriorly.

Holotype. Carnegie Museum no. 32205, an adult female collected August 10, 1953, four miles north of Van, Venango Co., Pa., by Neil D. Richmond.

Paratypes. All from Pennsylvania. C.M. 29382, 29384, Venango Co., 1 mi. NE. of Sadler's Corner; C.M. 32204, Venango Co., 4 mi. N. of Van; C.M. 32137-32146, 32244, Warren Co., 10 mi. SW. of Warren; C.M. 32219, Forest Co., 3 mi. SW. of Tionesta.

Description of type. Head scutes the same in number and arrangement as in the other two races of the species. Rostral almost triangular, slightly higher than wide, the tongue groove a pronounced notch; internasals two, small and triangular; prefrontals two, subquadrate, an extension from the posterolateral angle entering the orbit; frontal longer than wide, same length as distance from its anterior end to snout. Two nasals, the nostril in

*Contribution no. 4 from the Pennsylvania Herpetological Survey, a project sponsored by the Sarah Mellon Scaife Foundation, of Pittsburgh.



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the posterior margin of the anterior nasal. Loreal almost rectangular, longer than high, in contact with the orbit posteriorly, the upper anterior border of the orbit formed by a posterolateral extension of the prefrontal. Postoculars two on each side, the upper being the larger. Eye moderate, diameter greater than the height of the labials below it. Supra-ocular long and narrow, widest posteriorly; parietals long, widest anteriorly, narrowly separated from fifth supralabial, and in contact with upper postocular. Temporals one and two, the anterior the larger, lying in the angle formed by the fifth and sixth supralabial and narrowly contacting the upper postocular. Supralabials six, the fifth much enlarged. The third and fourth supralabials enter the orbit, the fifth is separated from the orbit by the postoculars. Infralabials six, the first pair meeting on the mid-ventral line. Infralabial four is the largest and contacts both the anterior and posterior chin shields. The sixth infralabial is separated from the first ventral by two rows of scales. Two pairs of chin shields, the first pair in contact throughout their length, the second pair diverging posteriorly and inclosing a small scale and the first ventral.

Dorsal scales glossy, without apical pits and all keeled except rows one and two, the first two much wider than others. The dorsal scale formula is 15-17-17, or expressed according to the system proposed by Dowling (1951):

$$15 - \frac{+ 3 (18)}{+ 3 (18)} - 17 - 17 (126)$$

The ventrals as shown in the formula, are 126 plus a divided anal plate, subcaudals 31 pairs plus a terminal spine. Total length, 310 mm.; tail length, 50 mm.; tail length, 16 per cent. of total length.

In alcohol, the dorsal color is uniform dark brown, gradually fading toward the sides and extending onto the tips of the ventrals. There is an irregular row of minute black flecks along scale rows four and five; these flecks cover less than half of a scale, and are barely visible. The ventral color is uniform whitish. The head is dark brown above, darker than the body. The side of the head has a dusky, almost black, shading on the postoculars and loreal, sharply delimited by the pale supralabials. The infralabials and chin are light like the belly.

VARIATION

The following discussion of variation in color and scutellation is based on 53 specimens (including the type and paratypes) from Pennsylvania.

In eight specimens, each has a small pre-ocular; in seven of these the pre-ocular is cut off from the prefrontal and in one the posterior end of the loreal is cut off. Only two specimens have a pre-ocular on each side.

The postoculars vary in number, size and shape. Sometimes they are almost displaced by a downward extension of the supra-ocular and an upward extension of the fourth supralabial. The number of postoculars ranges from one to three. In 52 specimens 30 have two, 15 have three, and 7 have one. There is no significant difference between the sexes in the

POPULAR SUMMARY

This paper constitutes the formal christening, in approved scientific fashion, of the first new snake discovered in Pennsylvania in 62 years!

The small, harmless Ground Snakes are so secretive in their habits that as late as 1923 there were only 30 specimens available from the entire eastern United States. During the work of the Pennsylvania Herpetological Survey, a Carnegie Museum project sponsored by the Sarah Mellon Scaife Foundation of Pittsburgh, Curator Richmond discovered the optimum weather conditions for collecting these snakes. As a result, Carnegie Museum now has 60 specimens from Pennsylvania alone. When this large series was studied, the snakes from the mountains of western Pennsylvania proved to be a form new to science.

The Mountain Ground Snake is believed to have entered Pennsylvania before the last glaciation and adapted itself to the long winter, cool summer climate of the unglaciated, high plateau during the thousands of years when ice covered much of western Pennsylvania. The small-headed garter snake, which is found only in the same region, probably had a similar history.

Additional copies of this paper may be obtained from Carnegie Museum, Pittsburgh 13, Pa. at twenty-five cents per copy.

THEORY OF THE EARTH

The theory of the earth is a branch of geology which deals with the origin and development of the earth and its various parts. It is a science which seeks to explain the causes of the various geological phenomena which we observe in nature.

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distribution of this variation. With one exception, the number of postoculars was the same on both sides of the head.

The number of labials is six upper and six lower on all but four specimens. Three of these have five lower labials on one side and six on the other, while the fourth specimen has five upper labials on one side and six on the other. The large fifth supralabial is always separated from the orbit, commonly by the lower postocular but sometimes by a projection of the fourth supralabial that extends between the orbit and the fifth supralabial.

Dorsal scale rows 15-17-17 in all but one specimen; C.M. 32206-H has 14-15-17-17 rows of scales, as the result of the loss of the mid-dorsal row opposite the twelfth ventral.

There is some variation in how far forward the third scale row extends, ranging from opposite the 44th ventral to opposite the 15th ventral, usually opposite ventrals 20-30. Usually the third row of scales begins at approximately the same place on each side. However, occasional specimens will show a great difference; for example, one with the third row on the right side starting opposite the 26th ventral and the same row on the left starting opposite the 44th ventral.

Variation in the number of ventrals and caudals is discussed under sexual dimorphism.

The color pattern varies in this series from uniform gray or brown to specimens that have a faint stripe on the mid-dorsal line bordered with flecks of black arranged in two irregular rows. Every specimen has a dark shadow around the eye, consisting of black pigment on the postoculars and loreal. On most specimens the labials and chin are immaculate white but some of the specimens from the northern counties show a tendency to melanism and have the labials and chin dusky. On these, the dorsal color is almost black and continues dark to the ends of the ventrals and is in sharp contrast with the white under side.

Living specimens are reddish brown rather than gray as most *valeriae*. The amount of black flecking is less than in *valeriae*. The pinkish color of the dorsal surface extends onto the ends of the ventrals, shading to a clear yellow on the mid-ventral line. Although the scales are keeled, they have a glossy surface and the keels are not easily seen without a lens. The pinkish tone of the dorsal and ventral colors, as well as the pale yellow of the mid-ventral line, so noticeable in living specimens, disappear rapidly in preservative.

OTHER SPECIMENS

In addition to the 53 specimens discussed above, there are two specimens from western Pennsylvania that deserve separate mention, one because of its history and the other as possible evidence of intergradation with *valeriae*.

Atkinson (1901), in "The Reptiles of Allegheny County, Pennsylvania," listed a specimen of *valeriae* that he had collected in Wilkesburg in 1899. On the basis of this report, Surface (1906) included *valeriae* in his list of the snakes of Pennsylvania. In 1928, Dr. Atkinson gave Carnegie Museum a collection of snakes in which was one specimen of *valeriae* with the same

data as that reported in 1901, and presumably the same snake. This specimen, C.M. 4763, is definitely *valeriae*. It is a female with smooth scales in 15-15-15 rows, 123 ventrals, and 25 caudals, and does not resemble the *Haldea* of western Pennsylvania. Wilkinsburg is completely outside of the known range of *valeriae* and is about forty miles west of the mountainous area where *pulchra* has been taken. In view of this the measurements and scale counts of this specimen were omitted from those of *pulchra*, and Allegheny County, Pa., is not included in the range of either form.

Of seven specimens from Somerset County, Pa., one, C.M. 26133 ♂, has scales in 15-15-15 rows with keels throughout, 119 ventrals. The tail is broken off this specimen at the 27th caudal. This specimen might be considered aberrant in having the scale-row formula of *valeriae*. On the other hand, the fact that the nearest known locality for lowland *valeriae* is in the Potomac Valley only some forty miles away suggests that intergradation with upland *pulchra* may occur in this area.

RANGE

This subspecies is apparently restricted to the unglaciated Allegheny High Plateaus and Allegheny Mountain section of the Appalachian Plateau Province from New York to West Virginia. Although no specimens are known from New York, it should occur in Allegany State Park. Southward it has been found along the mountains from Warren County to Somerset County, Pa. Two specimens of *Haldea* have been reported from Swallow Falls State Park, Garrett County, Md. (Lemay, 1952 and Cooper, 1948). It has not been possible to examine either of these; however, the scale counts of one as given by Cooper were 15-17-17-17, and it is presumably *pulchra*. Garrett County, Md., is on the Allegheny Plateau and adjoins Somerset County, Pa. *H. v. pulchra* should be looked for in similar habitat in the adjoining mountain counties of West Virginia.

Fig. 1 shows distribution of the two subspecies of *Haldea valeriae* in Pennsylvania.

Haldea IN WEST VIRGINIA

In West Virginia, *Haldea* has been found in the extreme southwest and the extreme northeast. The specimens examined all have smooth scales in 15-15-15 rows, and are referable to *Haldea valeriae valeriae*. In the east this form has apparently entered the state along the Potomac River and the population there is continuous with that of *valeriae* of the Piedmont and Coastal Plain. The population in the west occurs in the drainage area of the west-flowing tributaries of the Ohio and apparently is a northern extension of the population of *valeriae* in Kentucky and southern Ohio. No specimens of *Haldea* are known from the high mountains of West Virginia although the northern form should occur there.

SEXUAL DIMORPHISM

The following characters will distinguish the sexes of *Haldea valeriae pulchra*.

Caudals: males 38-45, average 41.4; females 31-37, average 33.7.

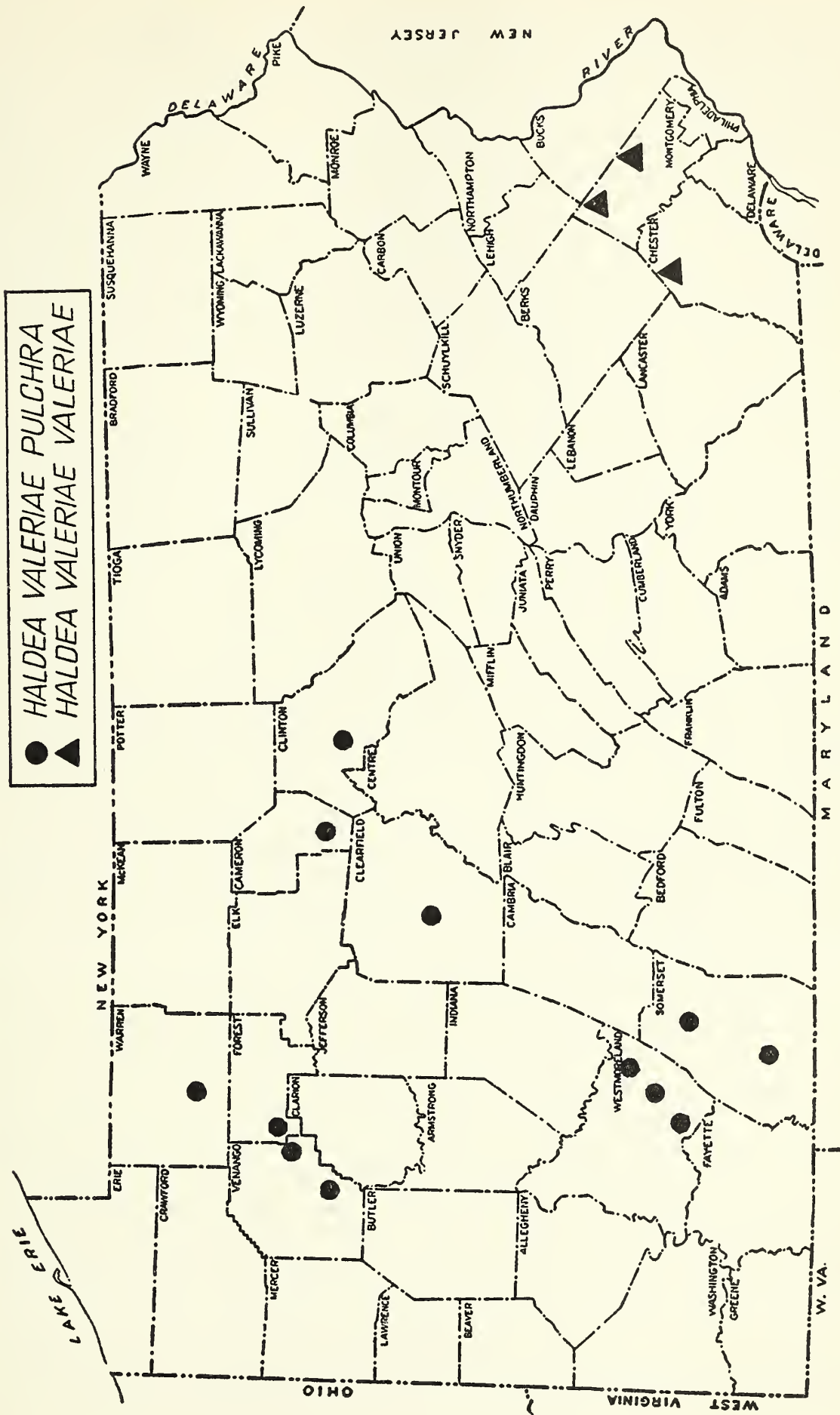


FIG. 1. Distribution of the two subspecies in Pennsylvania.

Proportionate length of tail: males 18.7-20.6 per cent., average 19.6 per cent.; females 15.1-17.9 per cent., average 16.7 per cent.

Ventrals minus caudals: males 74-82, average 77.6; females 84-97, average 90.8.

Other measurements and scale counts show sexual dimorphism, but not sufficiently to distinguish the sexes. In general, males have fewer ventrals and more caudals than the females. Combining these two counts reduces the amount of difference between the sexes, but there is still marked sexual dimorphism, making it necessary to use data for each sex separately for comparison with other members of the genus. Subtracting the number of caudals from the number of ventrals exaggerates the difference between the sexes and provides a useful check on sex determination of very small specimens.

In both sexes the umbilical scar occurs 11 to 16 scales anterior to the anal plate. The number of ventral scales anterior to the umbilical scar shows approximately the same amount of sexual difference as is seen in the total number of ventrals, indicating that the additional ventral scales of the female occur anterior to the umbilicus.

SIZE OF MATURE *Haldea*

In the mature snakes the longest specimens are females. The longest male is 277 mm. while there are five females of greater length, with the longest 320 mm. The average length for 10 males over 200 mm. long is 241 mm. while the average for 11 females over 200 mm. is 269 mm. The extremes for each sex are larger than those reported for *elegans* (Blanchard, 1923).

DESCRIPTION OF YOUNG

The following observations were made on four litters of *Haldea* born in the laboratory, between August 19 and September 14, 1953. The number of young in each litter was 5, 5, 7, 8. Adding the litter of five reported by Swanson (1952), the average litter size is six.

In total length the newly born young range from 95 mm. to 123 mm. In this series of 25 the shortest specimen is a female and the longest is a male. The mean total length for six males is 114 mm., compared with 109 mm. for 19 females. Most of this difference in total length is attributable to the longer tails of the males. In this series the sex can be determined by tail length alone, as in the males it ranges from 22 to 23 mm. (mean=22 mm.), while in the females the range is from 16 to 20 mm. (mean=18 mm.). The weight of 19 young ranged from 0.475 to 0.860 gram (mean=0.804 gram).

The sex ratio of these young is peculiar in that females greatly outnumber males, 19 to 6. However, this is within the theoretical limits for a sample of 25 specimens from a population in which the sex ratio is 50-50. The theoretical limits for a sample of this size are 5 of one sex to 20 of the other. (Simpson and Roe, 1939, p. 184.) This was true of each of the four litters, none of which had more than two males, while one litter consisted of five females. The 29 mature snakes have a normal sex ratio (15 ♂, 14 ♀).

The size at birth is surprisingly large compared to the size of the adult female. The average total length of each litter is 36 per cent. of the total length of the parent female. At birth they are larger than the young of either *Storeria dekayi* or *Storeria occipitomaculata*, which share the same habitats. Table 1 shows the size of newly born *Haldea* and three other species in the same habitat.

TABLE 1

Comparison of the size at birth of *Haldea valeriae pulchra* and three species associated in the same habitat. The females measured were the parents of the young measured. The number in parenthesis is the number of females measured of each species.

Name	Number of young measured	Average total length at birth in mm.	Average total length of female in mm.
<i>Haldea valeriae pulchra</i>	25	107	292 (4)
<i>Storeria dekayi</i>	17	96	295 (2)
<i>Storeria occipitomaculata</i>	63	98	360 (5)
<i>Thamnophis brachystoma</i>	20	147	435 (2)

When born the young are without markings, dull gray above and white beneath.

HABITAT

The preferred habitat appears to be grassy areas near or in forests. They are usually found under small rocks, boards or other cover and are most often found after heavy rains.

In the parts of Pennsylvania where these snakes occur, prolonged rainfall is usually associated with low temperatures so that following such a rain, *Haldea* and other small snakes are more likely to be found under stones that are warmed by the sun. At such times, *Haldea* may be collected in numbers that indicate their usual scarcity must be the result of a behavior pattern that makes them difficult to find. The experience reported by Swanson (1952) is typical of people who happen to find *Haldea* at the right time. "I looked in vain for this snake for twenty years; then in 1949, Borland, Shively and I caught eight in a few minutes." After several days of rain in April, 1953, Hal H. Harrison and I collected 10 in approximately one hour. This might be interpreted as evidence that *Haldea* lives in small isolated colonies. However, most of the locality records are based on individual specimens. Further evidence that rain makes them more available is offered by the results of a trip in August, 1953. On the first clear day after two days of rain, four specimens of *Haldea* were collected in three localities. The second day after the rain, only one specimen of *Haldea* was found, and on the third day none was found, although all of the localities visited were in areas where *Haldea* had been collected.

United States Weather Bureau records for these dates show that each date of collection was preceded by two to four days of rain with an average four-day total of 2.2 inches. Since the average monthly total is only three to

four inches in this area, it is apparent that optimum collecting dates followed periods of unusually heavy rainfall.

The following figures show the amount of rain in a four-day period preceding the date of collection, and the number of specimens collected.

Collecting date	Weather Bureau station	Inches of rain for each day before collecting date					No. of Haldea
		1	2	3	4	Total	
June 29, 1949	Franklin	0.08	0.36	0.81	0.58	1.83	8
May 27, 1953	Warren	1.06	0.00	0.00	2.37	3.43	10
Aug. 10, 1953	Franklin	1.03	0.32	0.00	0.04	1.39	4

DISCUSSION

Of the two previously known forms, *elegans* is the least specialized and presumably the more primitive. Although the new form is between *valeriae* and *elegans* in some characters (number of scale rows, number of ventrals, and size of eye) it is even less specialized than *elegans* in degree of keeling, body size and number of caudals. In all characters the montane form resembles *elegans* more than it does *valeriae* although it is about 500 miles from the nearest Indiana locality for *elegans*.

One explanation of the peculiar present-day distribution of the genus *Haldea* is that *valeriae* very early split off from a parent form with keeled scales arranged in 17 or more rows, and spread east and north along the coastal plain and Piedmont, while the prototype of *elegans* spread north and east in the interior until it reached western Pennsylvania prior to the Wisconsin glaciation and then became separated into two populations by the Wisconsin ice sheet, and that the montane population in the east persisted throughout the glacial period in or near its present range. Although the other forms of the genus are primarily southern, *pulchra* occupies the coldest and most northern unglaciated area in the eastern United States.

The range of *pulchra* is entirely within an area of very short cool summers. The average length of the frost-free season is 120-140 days, while the ranges of both of the other forms have a frost-free season of not less than 180 days, and the greater part of their ranges has 200-280 frost-free days.

All of the localities where *pulchra* has been taken have an average July temperature of 70° F. or less, compared with an average July temperature of 75° F. or more for the localities where *valeriae* and *elegans* occur.

This peculiar distribution resulting in a montane form in northern Pennsylvania with its nearest relative in the mid-west is similar to that of *Thamnophis brachystoma*, also restricted to northern Pennsylvania and with *Thamnophis butleri* of the mid-west as its nearest relative. Conant (1950) includes a statement by Netting postulating that both *butleri* and *brachystoma* were derived from some widespread pre-Wisconsin form, and that *brachystoma* also survived during Wisconsin times in or near its present range.

LOCALITY RECORDS

Haldea valeriae pulchra

Specimens examined, including the type and paratypes. (All numbers are Carnegie Museum numbers.)

Pennsylvania. Cameron Co. Gibson Twp. (28284-28285). Clinton Co. Keating (8842), Sproul Forest (12715). Forest Co. 3 mi. SW. of Tionesta (32219, 32220 A-G, 32221, 32222 A-E). Somerset Co. 5 mi. S. of Biglow Heights (21939-21944), 15 mi. SW. of Johnstown (26133). Venango Co. 1 mi. NE. of Sadler's Corners (29382-29384), 4 mi. N. of Van (32204-32205, 32206 A-H). Warren Co. 10 mi. SW. of Warren (32137-32146, 32244). Westmoreland Co. (5010), near Waterford (4886), near Laughlintown (21625), 3.5 mi. E. of Indian Head (27424), Pine Flat (29200).

Haldea valeriae valeriae

Pennsylvania. Berks Co. 7. mi. NNE. of Elverson (9654). Montgomery Co. Sumneytown (9695-9696), 2 mi. NE. of Prospectville (28710).

West Virginia. (C.M.=Carnegie Museum, W.B.S.=West Virginia Biological Survey collection.) Hampshire Co. near Romney (C.M. 23794-23795). Hardy Co. 1 mi. E. of Moorefield (W.B.S. 1945), 5 mi. S. of Moorefield (W.B.S. 1313). Kanawha Co. Belle (W.B.S. 2293). Lincoln Co. Ranger (W.B.S. 2439). Mineral Co. 3 mi. SE. of Keyser (C.M. 9028), Rawlings (C.M. 13826), Mingo Park (C.M. 13893). Wayne Co. Spring Valley (W.B.S. 2108). Wirt Co. Elizabeth (W.B.S. 1472).

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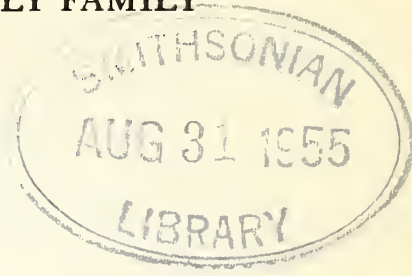
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ART. 16. REVISED CLASSIFICATION OF THE BUTTERFLY FAMILY
LYCAENIDAE AND ITS ALLIES

By HARRY K. CLENCH
Associate Curator, Section of Insects and Spiders,
Carnegie Museum



INTRODUCTION

For a number of years I have been intermittently engaged in a more or less detailed revision of the classification of the butterflies of the family Lycaenidae and of their immediate relatives. Because of the labor involved in completing such a task, as well as the many demands on my time, this study promises to be long in preparation. Since, however, investigations have been conducted to a point where useful and significant results are at hand, it was thought advisable to anticipate the larger work to a certain extent by presenting this outline of the higher classification of the group as it now seems indicated.

EXPLANATION OF SPECIAL TERMS

A number of relatively unfamiliar terms have been employed in the characterizations both to make them less cumbersome and to save space. These are discussed below.

Fore leg fully formed. Refers to the development of segmentation. A fully formed fore leg has femur, tibia and five articulating tarsal segments, armed at the tip with two articulating tarsal claws, pulvilli, and so on. Compare the following.

Fore leg reduced. Through fusion, especially of the tarsal segments, and some loss of parts, especially the tarsal claws and pulvilli but also some of the leg segments at times, as well as a more or less total reduction in size, the fore leg may become slightly to extremely smaller than either middle or hind leg (cf. Fig. 1, *p-s*).

Male fore tarsus. The following terms are applied to the apex of the fused male fore tarsus in the Lycaenidae, Liphyridae and Liptenidae: *stubby-tipped* (Fig. 1, *a, b, d, e*)—in lateral view, the ventral surface is either straight (Fig. 1, *d, e*) or curved, usually irregularly, dorsad (Fig. 1, *a, b*), but never curved ventrad. A variant of this, represented by Fig. 1, *d*, has the *apex reflexed*. In those forms with the apex *produced to a ventrally curved point or hook*, the ventral surface, in lateral view, is curved ventrally, along with the dorsal surface, as in Fig. 1, *c* and *f*. In such cases the apex is never reflexed.

Antennal sulci and carinae. A single sulcus is a groove or longitudinal depression on the ventral surface of the antenna, which may be continuous or composed of a series of pits, one to a segment. Two or three sulci may run parallel to each other. The carinae are raised longitudinal ridges, between and flanking the sulci (and found only in the Nymphalides). Dr. K. Jordan, in a paper that has been most undeservedly overlooked (1898, Nov. Zool. 5: 374-415, plates 14-15), has excellently surveyed the antennal characters of the butterflies.

Endodont. A tooth arising within the curve of the tarsal claw, projecting in roughly the same direction as the distal point of the claw (cf. Fig. 1, *h, i*, with *j*, where it is missing).

Macrotrichia. A pair of long spines or "bristles" arising on the dorsal surface of the last tarsal segment, very near the tip, and occurring also in the same approximate position on the fused fore tarsi of most (or all) forms which possess such tarsi (cf. Fig. 1, *a-g*).

Spines. Used in the prevalent sense—inflexible, pointed-elongate, articulating, unicellular processes on the ventral surface of the legs.

Spurs. Likewise the standard meaning is intended—inflexible, pointed-elongate, paired, articulating, multicellular processes arising near the apex of the middle and hind tibiae, on the ventral surface (cf. Fig. 1, *q, s*).

Dorsal, ventral leg surfaces. If the legs are imagined to be directed laterally straight out from the body these directions will apply literally. In their normal position the legs, of course, have no such clear-cut orientation, but for descriptive purposes it is essential.

Shaft/club ratio. The ratio of length of longest shaft segment of the antenna over length of average club segment. In those forms with an abruptly incrassate club the shaft segments tend to be much longer than the club segments; in forms with the antennal club gradually incrassate, often barely indicated, this ratio tends to be quite low, in some forms even approaching 1.0; that is, the shaft segments very little if at all longer than those of the club. This relationship, however, is far from precise.

SUMMARY CLASSIFICATION OF THE BUTTERFLIES

The following brief survey is given in order to orient the position of the group to be discussed in detail in its relations to other butterflies. Some differences between this classification and others previously presented by various writers will be noted. I hope and believe that these changes represent an improvement, but in any case the whole scheme must still be considered as extremely tentative, since so many characters (especially those of the legs) have as yet received only very cursory attention.

The most striking conclusion to emerge from a study of the butterfly groups and their interrelations is that, with the exception of the skippers, there is extremely little indication of differential associations of the various groups. The Hesperioidea are readily separable from all the others, and clearly approach an ancestral form from which the Papilionoidea have sprung. Beyond that we may perceive but little. Each group has a number of traits peculiar to it, or nearly so—the retention of the fore tibial epiphysis in the Papiliones, presence of the larval osmeterium in the same group; the tricarinate antenna, and the pupal suspension by cremaster alone (that is, lacking the silken girdle) in the Nymphalides (though also found in a few *Lycaenae*); and so on. These emphasize the long evolutive isolation that each major group ancestor must have had before beginning to subdivide into the presently known members of its group. There are, however, very few characters which could possibly point to any two of these being more closely related to each other than either is to any other. The only two of the four groups which do give some evidence of a relatively closer inter-

relationship are the Lycaenac and Pierides, with a few common characters or tendencies in the antennae (sulci), tarsal claws (endodont), venation, choice of plant food (especially the favoring of Leguminosae). Yet even here the enormous differences shown in male genitalia and in the entire structure of the pattern militate strongly against associating these two groups very closely.

I. SUPERFAMILY HESPERIOIDEA

Fore wing always with 5 radials, all free and unbranched from cell; antenna very often with apiculus; fore tibia usually with epiphysis, the fore leg fully formed in both sexes; hind leg usually with at least one pair, and often two, of tibial spurs; head broad, antennal origins widely separate.

A. Group HESPERIDES. Characters as above.

Families. HesperIIDae (including *Euschemon*) and Megathymidae.

II. SUPERFAMILY PAPILIONOIDEA

Fore wing with 5 or fewer radials; when 5, always with at least two stalked; antenna never with apiculus; fore tibia may have epiphysis or not, the fore leg fully formed in both sexes or more or less reduced in males only or in both males and females; hind leg never with more than a single pair of tibial spurs, and frequently with none; head narrower, antennal origins relatively close together.

A. Group PAPILIONES. Fore legs of both sexes fully formed, with tibial epiphysis; tarsal claw (Fig. 1, *k*) almost always without endodont, very long and slightly curved; antenna below irregularly and usually feebly bisulcate or non-sulcate, very rarely unisulcate, but never carinate; M_2 of fore wing usually arising distinctly closer to M_3 than to M_1 (cubitus "quadrifid"); pupa with girdle.

Families. Papilionidae, Parnasiidae, Zerynthiidae and Baroniidae.

B. Group NYMPHALIDES. Fore legs of male, and often of female, moderately to very strongly reduced, without tibial epiphysis; tarsal claw (Fig. 1, *l*) relatively small, without (always?) endodont, moderately strongly curved; antenna below bisulcate, tricarinate; M_2 of fore wing from midway between M_1 and M_3 or from closer to the former (cubitus "trifid"); pupa without girdle.

Families. Nymphalidae, Satyridae, Brassolidae, Morphidae, Apaturidae, Argynnidae, Callinagidae, Danaidae, Ithomeidae and Libytheidae. Many of these nominal families will require careful study before they can be admitted as families without qualification.

C. Group LYCAENAE. Fore legs of male most often moderately to strongly reduced, of females never reduced; fore tibial epiphysis absent; tarsal claw (Fig. 1, *i, j*) relatively small and strongly curved, without an inner tooth or with a short one not reaching apex of claw (save in one group, in which males have reduced fore legs); antenna ventrally feebly unisulcate or (most common) non-sulcate, never carinate; M_2 of fore wing from nearer M_1 than M_3 or (most commonly) from midway between (cubitus "trifid"); pupa usually with girdle.

Families. Liptenidae, Liphyridae, Lycaenidae and Riodinidae. See below.

- D. Group PIERIDES. Fore legs of both sexes fully formed, without tibial epiphysis; tarsal claw (Fig. 1, *h*) relatively small, strongly curved, with an endodont always present, always long, reaching to tip of claw; antenna ventrally unisulcate or trisulcate, never carinate. Fore wing with M_2 from midway between M_1 and M_3 or from closer to former (cubitus "trifid", but note the secondary return to "quadrifid" cubitus in the Dismorphiinae); pupa with girdle.

Family. Pieridae. This family divides so nicely and almost completely into two very neatly characterized subdivisions (to which *Pseudopontia* is an intermediate), that one is tempted to raise them to family rank. The presence of the annectant *Pseudopontia* (Africa), plus the remarkable homogeneity of facies, however, would make such a step unwise, at least at present. Since some of the available characters have not before been used (tibial spurs of hind leg), or have been ignored (sulci of antennae), a review of these groups here is not inappropriate. For references, additional details and further discussion see especially Klots (1933, *Entomologia Americana* (n.s.) 12: 139-242, "A Generic Revision of the Pieridae"), as well as Talbot (1932-1935, "Lepidopterorum Catalogus", partes 53, 60, 66; 697 p. Pieridae).

Family Pieridae

- a. Subfamily Dismorphiinae. Fore wing with 5 radials; cubitus "quadrifid"; antenna trisulcate; hind tibia without spurs; tegumen much reduced; uncus 2-lobed; harpes fused ventrally.
- b. Subfamily Pseudopontiinae. Fore wing with 3 radials; cubitus "trifid"; antenna unisulcate; hind tibia without spurs; tegumen much reduced; uncus 2-lobed; harpes fused ventrally.
- c. Subfamily Pierinae. Fore wing with 3-5 radials; cubitus "trifid"; antenna unisulcate; hind tibia with spurs; tegumen not greatly reduced; uncus simple or forked only near tip; harpes not fused for any great distance.

CLASSIFICATION OF THE LYCAENAE

1. Family LIPTENIDAE

Antennae moderately long (usually) to very short (Thestorinae), ventrally non-sulcate. *Eyes* rather large, naked in all members so far as known, not (or only slightly) emarginate opposite antennal origins. *Palpi* (Fig. 1, *m*, *n*) usually porrect, the third (terminal) segment almost always very small compared with the second, either in length or in bulk; first and second segments usually ventrally spinulose. *Venation*: veins on undersurface with or without semi-erect, evenly spaced spinules; fore wing usually, but not always, with 5 radials; M_2 of fore wing usually associated more closely with M_1 than with M_3 ; hind wing with humeral vein present or absent. *Legs* (Fig. 1, *a*, *b*, *p*): male fore leg with tarsus fused to a single ventrally spinose and always stubby-tipped segment, lacking tarsal claws (except Thestorinae, q.v., with fully formed male fore leg), the ventral spines extending to beyond level of macrotrichial origins; this spinosity of two different sorts (See below); fore leg (male) with tarsus much shorter than tibia; all legs with tibia spinose at least distally, and always lacking tibial spurs; hind leg with femur shorter

than tibia (except Durbaniinae, q.v.); tarsal claw always without endodont. Known larvae lymantrioid in form and phytophagous. (Only larvae of the subfamily Lipteninae are known, however.) Africa only.

- a. Subfamily PENTILINAE. Humeral vein present on hind wing; at least some veins below on hind wing, and occasionally on fore wing as well, with semi-erect, evenly spaced, spinules; palpus III less than $1/3$ length of palpus II (Fig. 1, *n*), and very stout; ventral spines of male fused fore tarsus (Fig. 1, *a**) apically in two similar rows, the number, angle of insertion and spacing of the spines very similar in each row; spaces between the last four spines in either row less than the space (diastema) between the fourth and fifth from tip; macrotrichia of fore tarsus as long as, or longer than, terminal ventral spine; hind leg with femur shorter than tibia (Fig. 1, *p*).

Known members:† *Pentila* (sp. near *rotha* Hewitson), *Telipna* (*bimacula* Plötz), *Pentila* spp., *Telipna*, *Alaena*.

- b. Subfamily DURBANIINAE. Humeral vein present on hind wing; veins of under surface without spinules; palpus III less than $1/3$ length of palpus II, and stout; ventral spines of fused fore tarsus of male apically in two dissimilar rows, an inner (mesad) row of erect, rather regularly spaced spines, with diastema between fourth and fifth from tip, and an outer row of sparse, declivent, irregularly spaced spines; macrotrichia of fore leg shorter than terminal ventral spine; hind leg with femur subequal to, or slightly exceeding, tibia.

Known members: *Durbania* (*saga* Trimen). *D. limbata* Trimen, *D. amakosa* Trimen, examined cursorily.

- c. Subfamily LIPTENINAE Röber 1892 (modified). Humeral vein absent; veins of under surface without spinules; palpus III about $1/2$ length of palpus II and slender; apical spines on fused male fore tarsus (Fig. 1, *b*) in two dissimilar rows—an inner (mesad) row of erect, closely and rather evenly spaced spines lacking the diastema between fourth and fifth from tip, and an outer row of sparse, declivent and irregularly spaced spines; macrotrichia of fore leg shorter than terminal ventral spine; hind leg with femur shorter than tibia.

Known members: *Liptena* (*simplex* Aurivillius), *Epitola* (*cercenoides* Holland, *posthumus* Fabricius), *Larinopoda* (*lircaea* Hewitson), *Teriomima*, *Citrinophila*, *Mimacraea*, *Pseuderesia*, *Micropentila*, *Epitolina*, *Argyrocheila*, *Eresina*, *Iridana* and *Powellana*.

- d. Subfamily THESTORINAE. Humeral vein absent; veins of under surface without spinules; palpus III less than $1/3$ length of palpus II, rather slender; antennae very short, reaching about $1/3$ out on costa;

* Spines of the far row omitted for the sake of clarity, as also on Fig. 1, *c-f*.

† Throughout the paper, species in parenthesis after the generic name are those which have been examined carefully for all structural characters used in preparation of this classification. Genera listed without specific names are by virtue of having been examined cursorily—generally without preparation of a slide, merely under the dissecting microscope, for a few critical characters.

male fore leg fully formed; hind leg with femur longer than tibia.

Known member: *Thestor* (*Arrugia* Trimen*) (*basuto* Wallengren). *T. brachycera* Trimen and *T. protumnus* Linnaeus examined cursorily.

2. Family LIPHYRIDAE

Antennae never very long and may be quite short (Spalginae), non-sulcate ventrally. *Eyes* always naked, so far as known, slightly to strongly emarginate opposite antennal origins. *Palpi* variable in length but segments II and III together always over half the length of hind tibia, and may be roughly twice as long. *Venation*: humeral vein always absent (except *Megalopalpus*, Gerydinae); veins of under surface never with any spinules; fore wing with 4 or 5 radials. Legs variable in many characters. Male fore tarsus may be fully formed or fused (Fig. 1, *c*) to a single clawless segment, always ventrally spined, though weakly so in some members; when the male fore tarsus is fused, the tip is produced to a ventrally curved point (all except Poritiinae, q.v.) and the ventral spines do not reach the level of macrotrichial origins (cf. near exception, Poritiinae); middle and hind tibiae without spurs, with or without ventral spines; tarsal claw always with endodont. Known larvae are almost all limacoid in form, and carnivorous. Africa, Asia, Indo-Australia, North America.

a. Subfamily LIPHYRINAE. Legs subcylindrical; male fore tarsus fully formed, longer than fore tibia; hind tarsus I shorter than II-V; shaft/club ratio less than 1.50; at least some basal segments of antenna completely scaled; uncus not abnormally large. Africa, Indo-Australia.

(1) Tribe LIPHYRINI. Fore wing with 5 radials; M_2 from midway between M_1 and M_3 . Moderate to large species, mostly rather uncommon in collections. Probably crepuscular in habit.

Known members: *Aslauga* (*leonae* Aurivillius), *Paraslauga* Bethune-Baker, *Euliphyra* Holland, *Liphyra* Westwood.

(2) Tribe DELONEURINI. Fore wing with 4 radials; M_2 originating closer to M_1 than to M_3 . Africa only. Very rare in collections. None has been seen, the pertinent characters having been taken from other sources, chiefly Aurivillius (1920, in Seitz, "Grossschmetterlinge der Erde," 13: 346) and Murray (1935, "South African Butterflies; a Monograph of the Family Lycaenidae": 39, 58; venation plate, fig. vi).

Known member: *Deloneura* Trimen.

(3) Tribe LACHNOCNEMINI. Fore wing with 4 radials; M_2 originating midway between M_1 and M_3 . Africa only. Very "lycaenid looking" and formerly placed in the Lycaenidae.

Known member: *Lachnocnema* (*magna* Aurivillius, *bibulus* Fabricius).

* Cf. F. Hemming, 1934. "Generic Names of the Holarctic Butterflies", 1: 113; W. Peters, 1952. "A Provisional Check-list of the Butterflies of the Ethiopian Region": 110 (Genus no. 161). I am indebted to N. D. Riley, of the British Museum, for calling my attention to this synonymy.

- b. Subfamily GERYDINAE. Legs subcylindrical or distally laterally compressed and distinctly blade-like; male fore tarsus fused to a single segment produced at tip to a ventrally curved point; feebly to moderately spinose ventrally, but not distad of macrotrichial origins; fore tarsus much longer than fore tibia; macrotrichia short, not reaching apex of fore tarsus; first tarsal segment of hind leg from two to more than three times as long as segments II-V of this leg; *Megalopalpus* with humeral vein on hind wing; shaft/club ratio less than 1.5; antennae ventrally unscaled to base; uncus much enlarged, dominating the whole male genital armature. Africa, Indo-Australia.

Known members: *Megalopalpus* (*metaleucus* Karsch, *simplex* Röber?); *Gerydus* (*leos* Guérin); *Allotinus* (*horsfieldi apries* Fruhstorfer); probably *Logania* Distant.

- c. Subfamily SPALGINAE Holland. Legs subcylindrical; male fore tarsus (Fig. 1, c) fused to a single segment produced at tip to a ventrally curved point, moderately spinose ventrally but not distad of macrotrichial origins; macrotrichia relatively long, usually reaching beyond tip of tarsus; hind tarsus I subequal to or but slightly longer than tarsus II-V; shaft/club ratio less than 1.5; at least some basal antennal segments completely scaled; uncus of male genitalia not abnormally large. Africa, Asia, Indo-Australia, North America.

Known members: *Spalgis* (*epius* Westwood), *Feniseca* (*tarquinius* Fabricius), *Taraka* (*hamada* Druce). The last of these heretofore has been placed with the "blues"!

- d. Subfamily PORITIINAE. Legs subcylindrical; male fore tarsus fused to a single segment, moderately spinose ventrally, the spines extending to, but not beyond, level of macrotrichial origins; male fore tarsus stubby-tipped, the apex reflexed; macrotrichia reaching beyond the tip of the segment; hind tarsus I slightly longer than hind tarsus II-V; shaft/club ratio 2.0 (in *Poritia*, at any rate). Indo-Australia.

Known members: *Poritia* (*erycinoides* Hewitson), and perhaps one or two other genera.

In addition to the above characterizations, *Poritia* has two unusual characters: a glandular (androconial?) area on either side of the base of the male abdomen; and a group of stout, semi-erect spines on the last unmodified abdominal sternite, and to a lesser extent on the two preceding sternites.

This group should probably be referred to the Lycaenidae s.s., with which it shares a number of (unfortunately not particularly decisive) characters. However, because of an equally anomalous position there, and above all because of the absence of tibial spurs, it has tentatively been placed in the Liphyridae.

3. Family LYCAENIDAE, s.s.

Antennae of moderate length, ventrally non-sulcate, the ventral surface scaling varying from almost complete to none at all. *Eyes* naked or hairy, usually considerably emarginate opposite the antennal origins. *Palpi* (Fig.

1, o) very variable in total length and relative length of segments II and III, but always with II+III over half, and never as much as twice, the length of hind tibia, at least in material examined. *Venation* very variable. Fore wing with 3-5 radials; Sc and R₁ of fore wing not infrequently anastomosed to a greater or lesser degree; humeral vein of hind wing absent. *Legs* (Fig. 1, d-f, q). male fore tarsus (Fig. 1, d-f) fused to a single ventrally spinose segment or, rarely and spasmodically in the family, with the male fore tarsus fully formed; tibial spurs present on middle and hind legs except in *Eumaeus* (*Strymon* group, q.v.); tip of fused male fore tarsus may be stubby (Fig. 1, d-e) or produced to a ventrally curved point (Fig. 1, f), and the ventral spines may or may not occur beyond the level of macrotrichial origins; tarsal claw without endodont (Fig. 1, j), or with a short one (Fig. 1, i), only rarely (*Aphnaeus* and a few allied genera) with the endodont reaching as far as the claw tip (that is, similar to the pierid, Fig. 1, h); hind femur nearly always as long as or longer than hind tibia (except *Brephidium* and allies; possibly others, though none have been seen); middle and hind tibiae with or without spines. World wide.

The following classification must be considered very tentative and provisional. Although based on characters which seem to be of some systematic import, the resulting groups in many cases appear highly polyphyletic. The material examined is still woefully insufficient to do this matter justice.

- a. *Amblypodia* group. Juxta (of male genitalia) present; tarsal claw with endodont; male fore tarsus (Fig. 1, d) stubby-tipped, the apex reflexed, not spined below level of macrotrichial origins. Asia, Indo-Australia.
Known members: *Amblypodia* (*micale* Blanchard), *Drina* (*donina* Hewitson), probably several other nearly related genera.
- b. *Pseudodipsas* group. Juxta present (Fig. 1, u); tarsal claw with endodont; male fore tarsus produced to ventrally curved point, not spined below level of macrotrichial origins. Indo-Australia.
Known member: *Pseudodipsas* (*eone* Hewitson).
- c. *Strymon* group. Juxta absent (Fig. 1, t); tarsal claw usually with endodont (Fig. 1, i); male fore tarsus (Fig. 1, e) stubby-tipped, spined beyond level of macrotrichial origins. World wide.
Known members: *Hypochrysops* (*polycletus rex* Boisduval), *Philiris* (*gisella* Staudinger [*grandis* Smith and Kirby] and others), *Incisalia* (*niphon* Hübner and others), *Strymon* (*saepium* Boisduval and others).

NOTE. *Deudorix* (*epijarbas* Moore) and *Waigeum* (*ribbei* Röber) appear to belong here also, though both have the male fore tarsal tip produced to a ventrally curved point. They do not appear to be particularly closely related to each other, but separately to some of those listed above. *Waigeum*, especially, appears very close to *Hypochrysops* in all characters except the fore tarsal tip. Another genus provisionally placed here is *Eumaeus* (*atala* Poey), agreeing in all characters save the absence of tibial spurs which with this one exception (and *Poritia* also, should that be transferred to the family) are present in all true Lycaenidae.

- d. *Hypolycaena* group. Juxta absent; tarsal claw with endodont; male fore tarsus produced to a ventrally curved point not spined below level of macrotrichial origins. Africa, Asia, Indo-Australia.
Known members: *Hypolycaena* (*erylus tmolus* Felder), *Zeltus*, "*Pseudonotis*" (actually *Hypolycaena* s.l.) (*danisoides* de Niceville), possibly *Lepatomyrina*.
- e. *Candalides* group. Juxta present; tarsal claw usually with endodont; male fore tarsus stubby-tipped, spined below level of macrotrichial origins. Almost certainly polyphyletic, but as defined, nearly world wide.
Known members: *Candalides* (*xanthospilos* Hübner and others), *Hypaurotis* (*crysalus* Edwards), *Iolaus* (*mildbraedi* Schulze).
- f. *Lycaena* group. Juxta present; tarsal claw without endodont (Fig. 1, j); male fore tarsus produced to a ventrally curved point (Fig. 1, f), spined below level of macrotrichial origins. Another almost certainly polyphyletic group; as defined, very nearly world wide.
Known members: *Brephidium* (*exilis* Boisduval), *Ialmenus* (*evagorus* Donovan, *Poecilmitis* (*thysbe* Linnaeus), *Niphanda* (*fusca* Bremer and Grey), *Lycaena* (*phlaeas americana* Harris and others), *Heliophorus* (*epicles* Godart and others).
- g. *Plebejus* group. Juxta present; tarsal claw with endodont; male fore tarsus produced to a ventrally curved point, spined below level of macrotrichial origins. World wide.
Known members: *Glaucopsyche* (*lygdamus* Westwood), *Lycaenopsis* (*pseudargiolus* Boisduval and Leconte), *Hemiargus* (*ceraunus* Fabricius), *Leptotes* (*cassius theonus* Lucas), *Thysonotis* (*apollonius* Felder and others), *Hemiolaus* (*caeculus* Hopffer).

Includes the great majority of the "blues." The last form mentioned has formerly been placed with the "hairstreaks," which it strongly resembles in facies.

Species incertae sedis (Lycaenidae). a. A large number of important and very diverse groups have not been included above—*Anthene*, *Curetis*, *Ogyris*, *Myrina*, the neotropical "Theclas" and many others. Most of these will undoubtedly fall into one or another of the groups proposed above, but just as certainly, many will require creation of additional groups. b. Several undoubted members of the Lycaenidae s.s., and for the most part of very diverse affinities, deviate from the great bulk of the family in having males with fully functional (albeit slightly reduced in size) fore legs, just as in females. These are as yet not placeable in the above scheme, which relies heavily on the characters of the reduced male fore tarsus. Some of these species and groups are:

Tomares Rambur (Palearctic).

Artopoetes pryeri Murray (Asiatic).

Theclopsis Godman and Salvin (Neotropics).

New genus, new species (near "*Candalides*" *sublutea* Bethune-Baker). (New Guinea).

Several other groups, mostly Asiatic.

4. Family RIODINIDAE

Antennae usually very long, often ventrally flattened or lightly unisulcate, especially distally; ventrally the scaling may be complete (that is, to within 5-10 segments of the tip), partial, or absent entirely. *Eyes* naked or hairy, slightly or not at all emarginate opposite antennal origins. *Palpi* never very large, often extremely small, even invisible *in situ* from above. *Venation* variable: Fore wing with 4-5 radials; Sc and R₁ not uncommonly anastomosed for a greater or lesser distance; hind wing with humeral vein always present; a basal vein-like thickening of the costa is found in part of the family; Rs and M₁ often stalked. *Legs* (Fig. 1, g, r, s): male fore leg always strongly reduced in size, occasionally being smaller than the palpus, the tarsal segments fused (rarely 2-3 non-articulating segments may be discerned), and never ventrally spined; tibial spurs may be present (Fig. 1, s) or absent (Fig. 1, r) on middle and hind legs, though when present they are often small and require a wet mount (balsam or otherwise) in order to be seen; tarsal claw with endodont small, usually present, but absent in some members; hind legs with femur and tibia usually subequal; middle femur may be more (Fig. 1, s) or less (Fig. 1, r) than combined length of middle tibia and tarsus I. World wide.

- a. Subfamily HAMEARINAE (new). Middle leg with femur shorter than tibia+tarsus I combined; tibial spurs absent; base of hind wing costa not thickened; tarsal claw without endodont.
- (1) Tribe HAMEARINI Stichel 1928 ("stirps"). Antennal club heavily and abruptly incrassate; shaft/club ratio 2.3 (so far as examined); hind wing veins Rs and M₁ stalked. Palearctic.
Known members: *Hamearis* (*lucina* Linnaeus). Probably also *Polycaena* Staudinger.
- (2) Tribe ZEMERINI Stichel 1928 ("stirps"). Antennal club slightly and gradually incrassate; shaft/club ratio 3.0-3.2; hind wing veins Rs and M₁ usually stalked, but in many *Dodona* not so. Asia, Indo-Australia.
Known members: *Dodona* (*durga* Kollar), *Zemeros* (*flegyas javanus* Moore).
- b. Subfamily EUSELASIINAE Kirby 1871. Middle leg with femur shorter or longer than combined tibia+tarsus I; tibial spurs absent; base of hind wing costa not thickened; tarsal claw with endodont.
- (1) Tribe EUSELASIINI Kirby 1871. Middle leg (Fig. 1, s) with femur longer than tibia+tarsus I; shaft/club ratio 2.0-2.5 hind wing veins Rs and M₁ not stalked. Neotropical.
Known members: *Euselasia* (*melaphaea* Hübner), *Hades* (*noctula* Westwood).

When an author names a higher category, such as a subfamily or a family, based on a generic name it would seem unavoidable that all subordinate categories containing the type genus should be credited to him by implication, even though he did not explicitly recognize them, unless such subordinate categories had been proposed previously by another person. On this basis I attribute the present tribe to Kirby.

- (2) Tribe STIBOGINI Stichel 1928 ("stirps"). Middle leg with femur shorter than tibia+tarsus I; shaft/club ratio 3.5-3.9; hind wing veins Rs and M₁ stalked. Asia, Indo-Australia.
Known members: *Stiboges* (*nymphidia* Butler), *Holodesmus* (*satraps* Smith and Kirby).
- c. Subfamily RIODININAE. Middle leg with femur shorter or longer than combined tibia+tarsus I; tibial spurs present; base of hind wing costa thickened or not; tarsal claw with endodont.
- (1) Tribe ABISARINI Stichel 1928 ("stirps"). Middle leg with femur shorter than tibia+tarsus I; base of hind wing costa not thickened; hind wing veins Rs and M₁ stalked; shaft/club ratio 4.0-7.0. Africa, Asia, Indo-Australia.
Known members: *Abisara* (*rutherfordi* Hewitson), *Saribia* (*tepahi* Boisduval), *Taxila* (*haquina fasciata* Moore), *Dicallaneura* (*decorata consul* Fruhstorfer), *Laxita* (*orphna* Boisduval).
- (2) Tribe HELICOPINI (new). Middle leg with femur shorter than tibia+tarsus I; base of hind wing costa not thickened; hind wing veins Rs and M₁ not stalked; shaft/club ratio 5.9 (so far as examined). Neotropics.
Known members: *Helicopis* (*cupido* Linnaeus). Probably *Methonella* Westwood also.
- (3) Tribe RIODININI Grote 1895 (by implication). Middle leg with femur shorter than tibia+tarsus I; base of hind wing costa thickened; hind wing veins Rs and M₁ not stalked except in *Stalachtis*; shaft/club ratio 2.7-4.0. Nearctic, Neotropics.
Known members: *Polystichtis* (*pelarge* Godman and Salvin), *Eurybia* (*nicaea* Fabricius), *Riodina* (*lysippus lysias* Stichel), *Thisbe* (*irenea* Stoll), *Apodemia* (*carteri* Holland), *Orimba* (*myrtis gelasine* Bates), *Pandemos* (*godmanii* Dewitz), *Stalachtis* (*phlegia* Cramer). Contains the great bulk of the New World Riodinidae and is, thus, by far the largest tribe in the family.
- (4) Tribe THEOPINI (new). Middle leg with femur longer than tibia+tarsus I; base of hind wing costa thickened; hind wing veins Rs and M₁ not stalked; shaft/club ratio 2.2 (so far as examined). Neotropical.
Known member: *Theope* (*eudocia* Westwood).

Species incertae sedis (Riodinidae). The genus *Corrachia* Schaus and the curious *Styx infernalis* Staudinger are unknown to me. The latter, indeed, has been placed (quite erroneously) in the Pieridae, because of the presence of fully formed fore legs in the male. Absence of the endodont, as well as a few peculiarities of the venation, suggest that its position might not be far from the Hamearinae, especially the tribe Zemerini. It is, indeed, the only riodinid with functional male fore legs.

Species incertae sedis (Lycaenae). A number of genera, known to me only by incomplete descriptions, can not be satisfactorily placed in their proper families. Chief among these are *Teratoneura* Dudgeon; *Cooksonia* H. H. Druce; *Sheffieldia* H. H. Druce. All these are African, and appear more

likely to be referred to the Liptenidae than to any other family in the Lycaenae, but the necessary facts are not at hand.

EXPLANATION OF FIGURE 1

- a. Male fore tarsus, *Pentila* sp. near *rotha* Hewitson (Liptenidae. Africa). The spines on the far side, similar to those shown, have been omitted for clarity, as on all the figures of male fore tarsi, except *b*.
- b. Male fore tarsus, *Liptena simplex* Aurivillius (Liptenidae. Africa), right leg.
- c. Male fore tarsus, *Spalgis epius* Westwood (Liphyridae. Indo-Australia).
- d. Male fore tarsus, *Amblypodia micale* Blanchard (Lycaenidae. Indo Australia).
- e. Male fore tarsus, *Incisalia culminicola* Staudinger (Lycaenidae. Neotropics).
- f. Male fore tarsus, *Poecilmitis thysbe* Linnaeus (Lycaenidae. South Africa).
- g. Male fore tarsus, *Helicopsis cupido* Linnaeus (Riodinidae. Neotropics).
- h. Tarsal claw, *Phoebis sennae* Linnaeus (Pieridae. Neotropics).
- i. Tarsal claw, *Hypochrysops polycletus rex* Boisduval (Lycaenidae. Indo-Australia).
- j. Tarsal claw, *Ialmenus evagorus* Donovan (Lycaenidae. Indo-Australia).
- k. Tarsal claw, *Papilio philenor* Linnaeus (Papilionidae. North America).
- l. Tarsal claw, *Phyciodes tharos* Drury (Nymphalidae. North America).
- m. Palpus II and III, *Epitola posthumus* Fabricius (Liptenidae. Africa).
- n. Palpus I, II and III, *Pentila* sp. near *rotha* Hewitson (Liptenidae. Africa).
- o. Palpus II and III, *Amblypodia micale* Blanchard (Lycaenidae. Indo-Australia).
- p. Hind, middle and fore leg (left to right), *Pentila* sp. near *rotha* Hewitson (Liptenidae. Africa).
- q. Hind, middle and fore leg (left to right), *Hemiolaus caeculus* Hopffer (Lycaenidae. Africa).
- r. Hind, middle and fore leg (left to right), *Helicopsis cupido* Linnaeus (Riodinidae. Neotropics).
- s. Hind, middle and fore leg (left to right), *Euselasia melaphaea* Hübner (Riodinidae. Neotropics).
- t. Male genitalia, *Hypochrysops polycletus rex* Boisduval (Lycaenidae. Indo-Australia).
- u. Male genitalia, *Pseudodipsas eone* Felder (Lycaenidae. Indo-Australia).

Magnifications: *a-l*, scale C; *m, o-s*, scale A; *n, t, u*, scale B.

CONTINUED ON PAGE 274

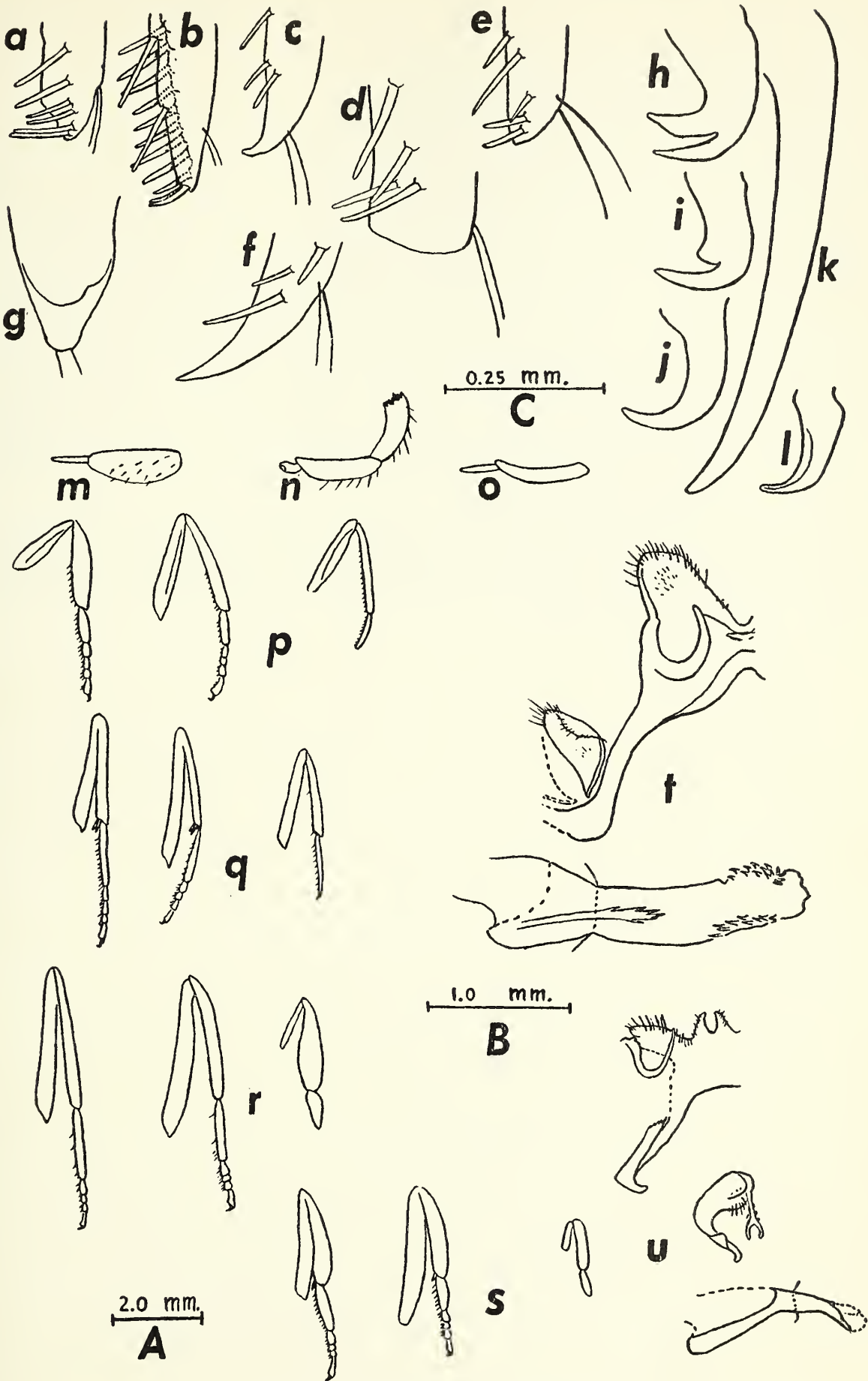


FIG. 1. STRUCTURAL DETAILS

In *a-g*, only outline, macrotrichia and ventral spines of near side (except *b*) are given.

Detail *h* is given to show long endodont of the Pieridae; *i* and *j* to compare presence and absence of endodont in Lycaenae.

In *m-o*, only the outline of the denuded segments, and the ventral spinules, when present, are given. In *p-s*, hair-scales and scales are omitted.

Details *t*, *u* are given primarily to compare presence (*u*) and absence (*t*) of juxta. Each of the two drawings shows right uncus lobe, tegumen, and falx; right half of vinculum; saccus; right valva, and penis.

In the preparation of the slides from which these drawings were made, the following procedure was employed. After softening and removing the genital structures in the usual way, the penis was removed; then the left vinculum was cut through, and the structures laid with ventral parts uppermost. Then the ventral parts (saccus and adjacent parts of vinculum, valvae, and juxta when present) were opened out to the left; the penis was next associated closely with the thus flattened structures and the whole mounted (balsam) in this flattened position. Thus the dorsal parts are seen in ventral aspect, the ventral parts in dorsal aspect, and the penis in lateral aspect. In those groups where it is feasible, this type of preparation provides the maximum exhibition of the most significant parts without distortion or foreshortening. Especially visible are the structures (when present) on the vinculum which in other types of preparation are almost always twisted or incompletely visible.

In the preparation on which detail *u* is based, complete success was not attained, as the left lower branch of the vinculum folded up to lie along the corresponding right part, and the valvae with the associated juxta became detached. Thus the saccus in the figure is seen as viewed from the right, and the valva was arbitrarily placed with its base to the top.

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ART. 17. LOCALITIES OF THE HERPETOLOGICAL COLLECTIONS MADE DURING THE "NOVARA REISE"

BY CARL GANS

Research Associate, Carnegie Museum

Recent work, involving forms of the genera *Dasypeltis* and *Liophis* mentioned in the *Novara* expedition reports made it necessary to re-examine the original travel descriptions. This resulted in the discovery of several interesting and apparently little known facts regarding the voyage and the collections resulting therefrom. Since some parts of the descriptions are no longer readily available, the following itinerary of the voyage and comments on the herpetological collections have been prepared in the hope that they might prove useful to others working on related problems.

On May 30, 1857, the Austrian Frigate *Novara* left Trieste on a circumnavigation of the globe. This voyage, designed primarily as a training venture for navy personnel, was also intended as an opportunity to "show the Austrian flag at more points of the world" (Scherzer, 1861, v. 1, p. 3). Secondary purposes were to be served by the accumulation of geological and natural history collections. To implement the latter and to engage in researches and observations in various fields, the expedition was accompanied by a scientific commission.

ITINERARY OF THE EXPEDITION

The scientific commission of the *Novara* consisted of seven naturalists* of whom five are mentioned in various places as having made natural history collections. These are Ferdinand Hochstetter, the geologist, Eduard Schwarz, the botanist, Karl Scherzer, the ethnologist-geographer, and finally Georg Frauenfeld and Johann Zelebor, the two zoologists.

Schwarz, Frauenfeld, and Zelebor stayed with the *Novara* for the entire trip, while Hochstetter remained behind in New Zealand, at the request of that government, to make a more thorough geological examination of that region. When the expedition arrived in Chile, it was informed of the outbreak of the Franco-German war, so it was decided to discontinue the trip and return directly to Trieste. Scherzer, however, left the *Novara* at Valparaiso to travel separately up the west coast of South America (by steamer) and did not rejoin the expedition until its arrival in Gibraltar. The detailed itineraries of both Hochstetter and Scherzer follow that of the expedition as a whole.

During the two-year voyage the *Novara* expedition visited and collected extensively in 18 areas, besides making short stops in a number of other localities. In the itinerary that follows, names in capitals, generally prefaced by Arr. (Arrived) or Left, refer to those ports or anchorages touched by the *Novara*, while all localities mentioned as having been visited by shore parties, are given below this in lower-case letters. Statements in parentheses refer to items of herpetological interest in the text.

* An eighth one started with the ship, but was debarked at Gibraltar.

AUG 25 1955



Besides the localities, the itinerary contains the dates on which the various localities were visited and the volume and page references of the descriptive reports. The latter are all cited from the German first edition (Scherzer, 1861-1862). Where the geographic designations used in the text were no longer up to date, more modern ones have been added in parentheses.

ITINERARY OF THE <i>Novara</i>			
<i>Date</i>	<i>Locality</i>	<i>Volume</i>	<i>Page</i>
1857			
30 April	Left TRIESTE	I	12
20 May	Arr. GIBRALTAR		29
	Campamiento and St. Roque, Spain		
	Algeciras		
30 May	Left GIBRALTAR		47
1 June	Anchored 15 miles N. of Malaga, Bay of FRANGEROLA		48
	No shore party, but visitors aboard.		
2 June	Left FRANGEROLA		51
8 June	Arr. FUNCHAL, MADEIRA		55
	Visit to N. of island, climb of Pico Ruivo		
	Porto San Jorge		
17 June	Left FUNCHAL		104
5 August	Arr. RIO DE JANEIRO, BRAZIL		119
	Corcovado		125
	Larangeiras		125
	Andarahy (Andaraí)		126
	Waterfall of Tejucas (Tijucas)		126
	(Notes on use of rattlesnake bite as cure for leprosy)		130
	Isla de Paquetá, Rio Bay (Paquetá)		144
	Other islands including Catalan (Catalão)		145
	Jujuba (encounter with Jararaca)		146
	Serra da Estrella (Estrela) and Petropolis		148
31 August	Left RIO DE JANEIRO		163
2 October	Arr. SIMONS BAY, CAPE COLONY		173
	Simonstown		175
	To Capetown via Chalk-Bay (Kalk-Bai)		176
	Zoologists make headquarters at Halfway		
	House between Capetown and Simons Bay		178
	Capetown		179
	Excursion from Capetown		191
	Stellenbosch		192
	Paarl		195
	Wellington, Waggon-maker's Valley, Baine's Kloof		196
	Darling bridge over Brid (Breede) River		197
	Worcester		198
	(Notes on paleontological material collected in Beauford by Dr. Meynard)		199
	Crossing of Brid River in Worcester Valley, Hot Wells of Brand Valley		200

<i>Date</i>	<i>Locality</i>	<i>Volume</i>	<i>Page</i>
1857			
	Rendén Farm	I	202
	Donker's Hoek		203
	Kleene Islea Plaats (Farm), near Zonderend (endless) River, Genaadendal (Mercy Valley or Bavian's Kloef)		204
	(Gift of natural history materials by Dr. Roser)		209
	Caledon		210
	Hauhoek and Sir Lowry's passes, Somerset West, Sandvliet Farm		211
	Macassar Down		212
	Capetown		215
	Constantia		218
	Cape of Good Hope		220
26 October	Left SIMONS BAY		221
19 November	Arr. ST. PAUL ISLAND		225
	Preliminary reconnaissance		232
20 November	Collecting party ashore		240
6 December	(<i>Novara</i> returns second time to pick up party)		253
7 December	Left ST. PAUL		255
7 December	Arr. AMSTERDAM ISLAND		262
	Landings on shore		267
7 December	Left AMSTERDAM		271
1858			
8 January	Arr. POINT DE GALLE, CEYLON		277
	Galle		285
	Dadala Pánzela temple		287
	(Mention of presence in Galle of geckos of the forms <i>Tachybates triedrus</i> and <i>Eurhous Leschenaultii</i>)		290
	(Snake charmers and cobras)		291
	(Taming of snakes, snake cults), the road to Colombo		292
	Bentotte		295
	Colombo		297
	Ratnapurta, Caltura		309
	Colombo		310
	(Use of herb oil as antidote for snake venom)		315
	Ratnapurta		318
	Gilli-mali, Adam's Peak		319
	Ratnapurta, Caltura		325
16 January	Arr. MADRAS, Coromandel Coast, India		328
20 January	Left GALLE (Saw sea-snakes)		326
	(Cobras, <i>Aspis naja</i> in the Zoological Park)		340
	Fort Vellore		346
	(Crocodiles)		347
	Arucati		349

<i>Date</i>	<i>Locality</i>	<i>Volume</i>	<i>Page</i>
1858			
	Sadras, Mahamalaipuram	I	353
	Lake Pulikat		364
10 February	Left MADRAS		367
23 February	Arr. N. side KAR NIKOBAR		367
25 February	villages of Moose and Sáui	II	11
27 February	Left N. side KAR NIKOBAR		25
28 February	Arr. S. side KAR NIKOBAR		25
	Kómios		26
28 February	Left S. side KAR NIKOBAR		28
4 March	Arr. TILLANGSCHONG		29
	Morroch Bay		29
6 March	Left TILLANGSCHONG		32
6 March	Arr. NANGKAURI		33
	Hóe		33
	Monghata Hill, Ulála Bay, Kamorta		
	Island		34
	Enúang or Enong, Nangkauri		34
	Malacca		35
11 March	Left NANGKAURI		39
18 March	Arr. TREIS, visited island, left		41
	Arr. off LITTLE NIKOBAR, visited Pulo		
	Milu, and left		45
19 March	Arr. N. of BIG NIKOBAR		45
	Kodul		45
	Big Nikobar or Sambelung		47
23 March	Moved N. to S. side of BIG NIKOBAR		51
28 March	Big Nikobar landing		52
28 March	Left NIKOBAR ARCHIPELAGO		53
	(Reptiles of the Nicobar Islands, Men- tion of " <i>Gonyocephali</i> , <i>Calotae</i> , <i>Eutropis multifasciata</i> , <i>Liotropis Ernesti</i> , <i>Lampropholis</i> sp. nov., <i>Ptychozoon homalocephalum</i> , <i>Typhlopes</i> , <i>Bothropes</i> , <i>Platurus fasciatus</i> , <i>Docidophryne</i> , <i>Crocodylus biporcatus</i> ")		74
	(<i>Chersydrus fasciatus</i> attacks chaplain aboard)		96
15 April	Arr. SINGAPORE, visit to island		98
21 April	Left SINGAPORE		127
5 May	Arr. BATAVIA (Djakarta), JAVA		129
13 May	Buitenzorg		146
14 May	Batoetoelis		152
	Pandok Gedeh		152
	Tjianjawar		155
	Tjipannas, foot of (Gununy) Pangerango		155
	Pangerango		156
	Tjiandur, Bandong		168
	Tji-sokan, Tji-sokan River, Tjitarum		
	[sic] River		171
	Lembang		172

<i>Date</i>	<i>Locality</i>	<i>Volume</i>	<i>Page</i>
1858			
18 May	Tangkuban Prah	II	178
	Bandong		180
	Tji-Tarum		182
19 May	Tjililin, Rongga District		182
20 May	Liotjitjangkang, Gunongatu, Tji		
	Burial, and Tji-Tangki Rivers		183
21 May	Tji-Lanang Valley, Tji-Tjamo Valley		
	Tjijabang, Tjuruk Baon		183
22 May	Tjuruk Alimun Falls of the Tji-Tarum;		
	Gua, foot of Gunung Nungnang		184
23 May	Sanjang Tjikoro Mt., Radjamandala,		
	Tjiandjur, Batavia		184
17 May	(Dr. J. Ch. Ploem of Tjiandur presents		
	natural history collection), Buitenzorg		187
20 May	Batavia		190
	(v. Schierbrand presents natural		
	history collection)		190
29 May	Left BATAVIA		197
15 June	Arr. CAVITE, LUZON, P. I.		197
	Manila		198
	Laguna de Bay		230
	Patero village		233
	Los Baños		235
	(Alligators)		238
	Calamba Swamps, Jallajalla,		
	Bianangonan		241
	(Living " <i>Boa constrictor</i> " seen. Dimen-		
	sions: 48 feet long, 7 inches thick)		247
25 June	Left CAVITE		248
5 July	Arr. HONGKONG, CHINA		250
	Travels on island		268
	Canton		269
	Macao		275
18 July	Left HONGKONG		291
26 July	Arr. WUSUNG (Shanghai)		294
	Shanghai		294
29 July	Moved WUSUNG to SHANGHAI		296
	Sikkawéi		340
11 August	Left SHANGHAI		383
18 September	Arr. PUYNIPET		400
	Landing		400
	(Small lizards with metallic-sapphire		
	blue tails noted.)		402
	(Turtles in native diet)		407
	(Natives produce 500 pounds of		
	tortoise shell annually)		423
18 September	Left PUYNIPET		
17 October	Arr. and left SIKAYANA (Big Island),		
	Stewart's Atoll		434
	Fáole, Sikayana		449

<i>Date</i>	<i>Locality</i>	<i>Volume</i>	<i>Page</i>
1858			
5 November	Arr. PORT JACKSON, SYDNEY, NEW SOUTH WALES	II	425
	Sydney	III	1
	Cambden's Park		17
	Campbelltown		22
	Appin		23
	Bargo		25
	Wulongong, Illawara District		26
	Hunter River, New Castle coal fields, Ash Island		43
	(Monitor lizards, Thorny lizards), Sugar Loaf Mountain		44
	Coggerah Bay		68
	Long Bay		69
7 December	Left PORT JACKSON		93
22 December	Arr. AUCKLAND		95
	Takapuna District		100
	Drury District, Judge Bay, Oraki Bay		136
	Oraki village		137
	Titarangi, Manukau Mountains		138
28 December	Otahus, Papakura Plain		143
	Tahake River		145
	Rama-rama		147
	Mangtawhiri River		149
28 December	Waikato River		152
31 December	Tuakau village		153
1859			
2 January	Auckland		156
8 January	Left AUCKLAND		160
	(Hochstetter, the geologist, remained on New Zealand for eight additional months before returning home separately. His itinerary is given after that of the <i>Novara</i>)		158
11 February	Arr. PAPEETE, TAHITI		176
	Pointe Venus		
	Matavai village		195
	Fautáua Falls		196
	Lake Waiiria		199
	Faáa		201
28 February	Left PAPEETE		220
17 April	Arr. VALPARAISO, CHILE		245
	Valparaiso (Valparaíso)		247
	(Gift of zoological collection by Dr. C. Seget of Santiago de Chile, also by F. Leybold)		255
	Santiago de Chile (Santiago)		258
	Casa blanca, Curacaví (Casablanca)		259
	Maipu		270
	Melepilla (Mellipilla)		272

<i>Date</i>	<i>Locality</i>	<i>Volume</i>	<i>Page</i>
1859			
	Guillota (Quillota)	III	274
11 May	Left VALPARAISO		284
	(Scherzer, the ethnologist, left the <i>Novara</i> here, to travel separately up the west coast of South America, rejoining the <i>Novara</i> in Gibraltar. His itinerary follows that of Hochstetter)		283
1 August	Arr. GIBRALTAR		400
7 August	Left GIBRALTAR		401
20 August	Gravosa, Dalmatia		402
21 August	Arr. RAGUSA, ITALY		402
26 August	Arr. TRIESTE		407

ITINERARY OF HOCHSTETTER

1859			
January-February	Auckland Province explorations	III	161
	Port Manukau, Waikato Mouth on W. Coast, Drury and Papakura districts, Waikakere Mouth, Wangaparao Peninsula (Gift of zoological material)		163
6 March	Up Waikato River, and Waipa River		164
	Whaingaroa, Aotea and Kawhia on W. Coast, Mokau District to sources of Wanganui River in Tuhua District, Lake Taupo, E. coast at Maketu, Port Tauranga, Waiho Valley at Rangia-whia, Auckland		165
	Cape Colville Peninsula, E. shore of Hauraki Gulf, Coromandel Port		166
28 April	Left Auckland; New Plymouth		
1 August	Wellington, Middle Island		
3 August	Nelson, Blind Bay, Golden Bay		169
	(Received gifts of zoological material)		170
	Sydney, Melbourne, Gold fields; returned to Europe via Mauritius		172

ITINERARY OF SCHERZER

1859			
17 May	Coquimbo, Caldera, Chile	III	297
20 May	Cobija, Bolivia (Punta Cobija, Chile)		299
	Iquíque, Peru (Chile)		300
21 May	Arica, Peru (Arica, Chile)		300
22 May	Chimba, Peru		301
22 May	d'Islay (Punta Islay)		304
23 May	Chala		307
24 May	Pisco		307
	Chincha Island (Islas de Chincha)		308
	Callao		313
	Lima		315
	Cajamarquilla in Rimac Valley		329

<i>Date</i>	<i>Locality</i>	<i>Volume</i>	<i>Page</i>
1859			
	Chorillos	III	338
	Pachacamác (Pachacamac)		335
14 June	Huanchaco		371
15 June	San José de Lambojeque, Chota District (San José, Depto. Lambayeque)		372
15 June	Payta (Paíta)		372
20 June	Taboga Island (Panamá)		375
21 June	Panama (Panamá)		376
21 June	Paraiso, Culebra, Matachin		386
	Barbacoa, Aspinwall (Colón)		387
23 June	Left Colon (Colón)		389
25 June	Cartagena, Venezuela (Colombia)		
30 June	St. Thomas		390
	(Gift of zoological material by A. Riise)		391
1 July	Left St. Thomas		391
18 July	Falmouth, England		397
19 July	Southampton, London		
27 July	Left for Gibraltar to rejoin the <i>Novara</i>		389

LITERATURE OF THE EXPEDITION

The records of the voyage were compiled and written by Scherzer, and were published almost simultaneously in Vienna and London (See Scherzer 1861-1862, and 1861-1863). The German edition only was reprinted in 1864-1866.

A secondary record regarding the voyage may be obtained by comparing the various letters and reports written by members of the expedition and published mainly in the *Sitzungsberichte der . . . Akademie der Wissenschaften, Wien*. Several members of the staff also appear to have written for the newspapers. As far as could be determined these reports are in good agreement with Scherzer. For the convenience of those who may wish to confirm details, an annotated, but by no means complete, set of references pertinent to the discussion has been appended.

The herpetological collections, stated to consist of 950 "Amphibien" (Scherzer, 1862, p. 410), were first examined by Fitzinger, who reported on them and the mammals collected by the expedition in a paper read before the kaiserliche Akademie der Wissenschaften zu Wien (1861). In this report the localities are just the major stops of the *Novara*, and no further details as to site of collection or number of specimens obtained were given. A number of new names were proposed in this paper.

The official reports on the collections were prepared by Steindachner (1867*a*, 1867*b*).^{*} He stated that he disagreed with a number of Fitzinger's

^{*}The two sections were first published separately in 1867 (See British Museum . . . AUSTRIA-HUNGARY). They were, however later republished as volume one of the zoological series at the time of completion of the last section, the complete volume bearing only the date 1869 on the title-page. This has resulted in a number of erroneous citations of the paper.

determinations and new descriptions, and generally gives Fitzinger's names in the synonymy under the new determinations.

The Steindachner reports do, however, contain a number of most puzzling entries which necessitate exercising considerable caution in their use. The specimens collected by the *Novara* expedition were at first kept in a special exhibit, the "Novara Museum" in Vienna, and were only later added to the official collections of the Naturgeschichtlichen Museums zu Wien. During this time there appear to have been added some collections presented to the expedition, often from localities not visited by the *Novara* or its staff. These donations as well as specimens from entirely different collections are included in Steindachner's report, sometimes without special reference to the fact that they were of diverse origin.

To give a few selected examples for these various cases there are "*Emys hamiltonii*", "*Pangshura tecta*", and "*Hemidactylus frenatus*", collected near Calcutta by Dr. Stolička, "*Sternotherus nigricans*", and "*Pachydactylus ocellatus*" from Madagascar by Frau Ida Pfeiffer, "*Ophryoessoides dumerilii* nov. spec." from Para, Brazil, by Joh. Natterer, much other material by the same collector also being mentioned. The prize example, though, is "*Pyxicephalus cordofanus* n. sp." from Cordofan (Anglo-Egyptian Sudan) a locality not likely to be visited by any frigate.

There is also a series of forms donated by Steindachner himself, for example, "*Pachydactylus ocellatus*", and "*Phyllodactylus lineatus*", as well as specimens collected by expedition members during previous voyages such as "*Crocodylus acutus* (v. Frauenfeld, Ecuador).

Steindachner finally also refers to material in the Naturgeschichtlichen Museum zu Wien as well as other institutions (Mus. Havn.) and for some forms he simply states the "Fundort" (locality where found), without indicating whether he had a specimen in hand.

In spite of the above, it is generally possible to distinguish the materials of the various categories mentioned as the number of specimens from the proper collections of the *Novara* is generally given together with a reference to the member of the military or scientific staff who collected them. Cross checking between names and localities permits a definite answer in most cases, but, in view of the evidence listed above, such scrutiny is an absolute necessity.

This paper was compiled while working in Brazil under a John Simon Guggenheim Memorial Fellowship during 1953-1954. The use of the facilities of the Departamento de Zoologia, Secretaria de Agricultura, São Paulo, and the help from members of its staff are also gratefully acknowledged.

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FITZINGER, LEOPOLD J.

1861. Die Ausbeute der österreichischen Naturforscher an Säugethieren und Reptilien während der Weltumsegelung Sr. Majestät Fregatte Novara. Sitzber. kais. Acad. Wiss., Mathem. Naturwiss. Classe, Wien, v. 25, no. 25, p. 383-416.

SCHERZER, KARL VON

- 1861-1862. Reise der oesterreichischen Fregatte Novara um die Erde, in den Jahren 1857, 1858, 1859, unter den Befehlen des Commodore B. von Wüllersdorf-Urbair. Wien, Kaiserlich-königliche Hof und Staatsdruckerei. 3 v. 1861-1862. Band I mit 5 Beilagen 1861. xii+368+(2)+39 p., 14 plates, 34 cuts in text, 8 maps. Includes chapter of instructions by A. v. Humboldt entitled, "Physikalische und geognostische Erinnerungen." Folding map and errata slip loose in back pocket. Band II mit 7 Beilagen. 1861. viii+454+(2)+28 p., 8 plates, 70 cuts in text, 15 maps. Subtitle: "Beschreibender Theil." Band III mit 9 Beilagen. 1862. viii+436+(2)+3+8+(1)+8+(1) p., 18 plates, 63 cuts in text, 11 maps. Subtitle: "Beschreibender Theil." Errata sheets for v. 2-3 bound at end of volume.
- 1861-1863. Narrative of the circumnavigation of the globe by the Austrian Frigate Novara . . . London, 3 v., illustrated. V. 1 contains a preliminary chapter by A. v. Humboldt entitled, "Physical and geognostic suggestions."
- 1864-1866. Reise der oesterreichischen Fregatte Novara um die Erde . . . Beschreibender Theil, Zweite Auflage. Wien, 3 v., illustrated.

STEINDACHNER, FRANZ

- 1867a. Reptilien. *In* Reise der österreichischen Fregatte Novara . . . Zoologischer Theil, erster Band, Wirbelthiere. 98 p., 3 plates.
- 1867b. Amphibien. *In* Reise der österreichischen Fregatte Novara . . . Zoologischer Theil, erster Band, Wirbelthiere. 70 p., 5 plates.

Letters and Articles Not Cited in Text

FRAUENFELD, GEORG

1858. Notizen über die Fauna Hongkong's und Schanghai's, gesammelt während des Aufenthaltes Sr. Majestät Fregatte Novara im Sommer 1858. Sitzber. math. naturwiss. Classe. kais. Akad. Wiss., Wien, v. 35, no. 10, p. 241-272 [*not* 172]. Report on Hongkong visit. Mentions some reptiles and amphibians on p. 245.
1859. Notizen, gesammelt während meines Aufenthaltes auf Neuhol-land, Neuseeland und Taiti, bei der Fahrt Sr. Majestät Fregatte Novara in jenen Gewässern. Sitzber. . . . Wien, v. 38, no. 26, p. 717-748. Notes on the voyage through the islands. Few mentions of reptiles.

1859. Bericht des Herrn Custos-Adjuncten G. Frauenfeld über den Erfolg der ihm gewordenen Mission: die Weltumsegelungs-Expedition S. M. Fregatte Novara als Zoologe zu begleiten. Sitzber. . . . Wien, v. 38, no. 27, p. 814-820.
Final report of the zoologist. Mentions 500 "Amphibien."
1859. Mein Aufenthalt auf Taiti. Verhandl. kais.-könig. zool.-bot. Gesell. Wien, v. 9, no. 3/4, p. 183-198.
Notes on excursions on Tahiti.

HAIDIGER, W.

1858. Drei Briefe von der Expedition der k. k. Fregatte Novara, von Singapore erhalten und mitgetheilt. Sitzber. . . . Wien, v. 30, no. 3, p. 175-190.
Letters of v. Wüllersdorf, Scherzer, Hochstetter, with notes on the trip to Singapore, collections, etc. Mention of "Novara Museum."
1859. Neuste Nachrichten aus Sydney vom 10. November 1858. Sitzber. . . . Wien, v. 34, no. 2, p. 73-76.
Description of the trip from China to Australia.
1859. Vorlage eines Schreibens von Herrn Dr. F. Hochstetter. Sitzber. . . . Wien, v. 34, no. 3, p. 203-206.
Travels in Australia
1859. Schluss des Aufenthaltes S. M. Fregatte Novara in Sydney. Sitzber. . . . Wien, v. 34, no. 5, p. 362-366.
Lists of Australian animals donated to the collection. Reptiles listed on p. 364.

HOCHSTETTER, FERDINAND

1859. Notizen über einige fossile Thierreste und deren Lagerstätten in Neu-Holland, gesammelt daselbst während des Aufenthaltes Sr. Majestät Fregatte Novara im Monate December 1858. Sitzber. . . . Wien, v. 35, no. 10, p. 349-358.
Australian fossils.

KOLLAR, V.

1858. Aus einem Schreiben des mit der kaiserlichen Fregatte Novara reisenden Zoologen, Johann Zelebor. Sitzber. . . . Wien, v. 30, no. 2, p. 171-174.
Notes on Gibraltar, Madeira (some amphibians collected), Rio de Janeiro, Cape of Good Hope, St. Paul, New Amsterdam, Ceylon, and Madras. Mentions shipment of specimens from Madras.
1858. Zweiter Bericht über die zoologischen Sammlungen des mit der kaiserlichen Fregatte Novara reisenden Naturforschers Johann Zelebor. Sitzber. . . . Wien, v. 31, no. 19, p. 226-228.
Notes on collections made to and including Batavia. No mention of amphibians and reptiles.

SCHAUB, VON

1856. Auszug aus einem Schreiben des Herrn Dr. Schaub in Trieste an den General-Secretär. Sitzber. . . . Wien, v. 22, p. 288.
The original invitation to send two naturalists with the *Novara*.

SCHERZER, KARL VON

1858. Aus Dr. Karl Scherzer's Mittheilungen an die k. Akademie über einige, während des Aufenthaltes Sr. M. Fregatte Novara in Funchal (Madeira) und Rio de Janeiro gewonnene Resultate. Sitzber. . . . Wien, v. 28, no. 3, p. 175-176.
On curare.

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ART. 18. SYSTEMATIC NOTES ON NORTH AMERICAN BIRDS

1. The Herons and Ibises (Ciconiiformes)

BY KENNETH C. PARKES

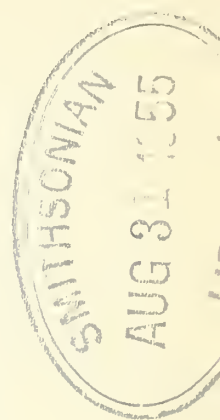
Associate Curator of Birds, Carnegie Museum

This is the first of a series of papers on the systematics and nomenclature of certain North American birds. Most of the research was done between 1947 and 1952, in connection with a study of the taxonomy of the birds of New York submitted to Cornell University as a Ph.D. thesis. This work was based primarily on the specimens in the collections of Cornell University and the American Museum of Natural History, supplemented by specimens borrowed from or seen at various other museums. I have subsequently checked many of my findings with the material available at Carnegie Museum, and have consulted pertinent recently published literature. At the end of this first paper will be found a list of the institutions and individuals to whom I am indebted for loans of specimens or for other help and advice.

1. *Ardea herodias*

I have not encountered in the literature the suggestion that the Great Blue Heron (*Ardea herodias*) be considered conspecific with the Gray Heron (*A. cinerea*) of the Old World, but I can find no important reason why this step should not be taken. Lowe (1954: 16) has come closest by describing *herodias* as "a replacing species so closely related [to *cinerea*] that it is most probably a subspecies which has achieved specific rank, the two together forming a 'superspecies'." The two are obvious geographic representatives (See maps, Lowe, 1954: 26-27). Judging from descriptions in the literature, from photographs, and from accounts of those of my friends who have seen *cinerea* in life, the habits, behavior and general appearance in nature of the two herons are all very much alike. The well known *A. c. cinerea* is substantially smaller than most races of *A. herodias*, but the large *A. c. firsas* of Madagascar equals or exceeds in size some of the smaller American races. The most striking color difference involves the presence of much rusty in the plumage of *herodias*, the equivalent areas of *cinerea* being white or gray. This color is, however, geographically variable, the rusty being much paler in some subspecies than it is in the northeastern *A. h. herodias*. Although adult *cinerea* is whiter than adult *herodias*, and lacks the rusty color entirely, the immature *cinerea* shows some rusty in exactly the places where it appears in adult *herodias*. In turn, the immature *herodias* is more rusty than the adult, possibly indicating that the rusty color is a more primitive condition in this group of birds, and that the American forms are nearer in color to the basic stock from which both *herodias* and *cinerea* arose.

The question of nomenclature now arises. If the Gray and Great Blue Herons are to be considered as one species, what shall the specific name be? Linnaeus named both on the same page (*Systema Naturae*, ed. 10, 1, 1785: 143). Although, as correctly shown by Amadon (1955), revisers are not obligated by the International Rules of Zoological Nomenclature to recognize line anteriority, it is convenient to do so, all other things being equal.



In this instance the name *cinerea* appears on the page before the name *herodias*, so as first reviser I designate *cinerea* as the name for the combined species. This treatment conforms with the nomenclature of most holarctic species; with few exceptions (e.g., *Falco columbarius*, *Loxia leucoptera*) the nominate subspecies is an Old World form (e.g., *Falco peregrinus*, *Loxia curvirostra* and many others). The subspecies of the Great Blue Heron would thus be listed as subspecies of *Ardea cinerea*, the northeastern race for example being known as *Ardea cinerea herodias* Linnaeus.

2. *Casmerodius albus*

Berlioz (1949: 27) advocated placing this species in the genus *Egretta* (type, *Ardea garzetta* Linnaeus), and this treatment is followed in much of the modern European literature. While I favor the expansion of the genus *Egretta* (See below), I feel that *Casmerodius* is out of place in this assemblage. The species of *Egretta* are all small, slender herons, while *Casmerodius* is a much larger, heavier bird, with a longer neck in proportion to body size. There are certain differences in feathering; *Casmerodius* lacks the occipital nuptial plumes typical of *Egretta*, but has the lower mandible more extensively feathered than do any of the smaller species. Several species in the genus *Egretta* (as expanded by several modern authors) are dimorphic, with both white and colored phases; *Casmerodius* is never, to my knowledge, dimorphic. In its appearance in life, *Casmerodius* has always reminded me more of *Ardea* than of *Egretta*, and it is interesting to note that Adams (1955: 60) has found at least one skeletal component, the ectethmoid bone, in which *Casmerodius* does, indeed, agree with *Ardea* rather than with *Egretta* ("*Leucophoyx*" of Adams's paper). All in all, I believe that the retention of the genus *Casmerodius*, even though it is monotypic, is justified.

3. "*Leucophoyx*" *thula*

I agree with Berlioz (1949: 22) that there is no justification for the recognition of a monotypic genus, *Leucophoyx* Sharpe, for the Snowy Egret of the New World. This species and *Egretta garzetta* of the Old World might well be considered members of a single superspecies. The only significant difference between the two lies in the structure of the nuptial plumes, especially those of the occipital region. In *thula* these are dissected and recurved, while in *garzetta* they are narrow and ribbon-like. There is also a difference in size, *garzetta* being somewhat larger. There is no basis here for a generic separation, and I advocate the use of the combination *Egretta thula* (Molina) for the Snowy Egret.

4. *Florida caerulea*

If the genus *Egretta* is to be expanded to include the Reef Herons (*Demiegretta*), as in some recent publications (cf. Smythies, 1953: 530), I believe that serious consideration should be given to the inclusion of the Little Blue Heron (*Florida*) as well. The plumage of the dark color phase of *Demiegretta sacra* is not unlike that of adult *Florida caerulea*, both in color and texture. The Little Blue Heron is unique in that its white plumage is restricted to immature birds, but this should not be enough to

exclude it from an expanded genus *Egretta*. The close relationship of these genera is emphasized by the hybrid *caerulea* × *thula* described by Sprunt (1954).

Judging by the names used in recent publications, there is much division of opinion as to the need for recognition of two subspecies of the Little Blue Heron. Those who recognize two races use the name *Ardea caerulescens* Latham (Index Ornithologicus, 2, 1790: 690), type locality Cayenne, for birds of Mexico and the West Indies south through South America, following the original suggestion of Riley (1904:279). Among the advocates of this division have been Wetmore (1927: 294) and de Schauensee (1948: 360). Friedmann, Griscom and Moore (1950: 29) called Mexican specimens *F. c. caerulea*, indicating their support of the division by the use of the trinomial, while they pointed out in a footnote the confusion existing with respect to the identification of Little Blue Herons from Mexico and Central America. Authors opposed to the subspecific division include, among others, Todd (1916: 180), Peters (1929: 133) and Hellmayr and Conover (1948: 191, footnote).

As suggested by Todd (1916: 180), individual variation in color in adult Little Blue Herons is most impressive. I have made direct color comparisons of adults from New York, Virginia, Florida, Louisiana, Texas, Cuba, Puerto Rico, Antigua, St. Lucia, the Grenadines, Sinaloa, Panama, Colombia, Venezuela, Ecuador and the Guianas. I find no correlation between color variation and distribution. On this account I reject the supposed darker subspecies *caerulescens* and use a binomial for the Little Blue Heron.

5. *Butorides virescens*

The Green Herons of the *virescens* group and the Striated Herons of the *striatus* group have been listed as separate species by most if not all modern authors, although reluctantly so by Hellmayr and Conover (1948: 184, footnote). There is much uncertainty as to their status in areas where their respective ranges supposedly overlap. The data from Barro Colorado Island, Panama Canal Zone, presented by Van Tyne (1950: 5) and Eisenmann (1952: 12) suggest that intergradation between the two groups may take place in that area. The two forms are also reported to meet on Margarita Island, off the coast of Venezuela. Lowe (1907: 554-555) believed the subspecies *robinsoni* of Margarita to be a connecting link between *striatus* and *virescens*. He used the name *Butorides virescens robinsoni*. Since *striatus* and *virescens* were first named by Linnaeus on the same page (Systema Naturae, ed. 10, 1, 1758: 144), the first reviser has the privilege of selecting a specific name for the combined group. I consider that this was done by Lowe; if further study shows that combining the two species is indeed justified, the races of *striatus* will become races of *virescens*.

The well known *Butorides virescens virescens* occupies a vast area extending from South Dakota to Chiapas and from New Brunswick to Florida. In view of the great plasticity exhibited by this genus elsewhere in its range, there is surprisingly little geographic variation within the range of *virescens*. In making direct comparisons of birds from New York, Pennsylvania, Ohio,

Maine, Virginia, North Carolina, Georgia and Florida, I have found no appreciable differences correlated with distribution. I have not examined Mexican specimens.

6. *Botaurus lentiginosus*

Meinertzhagen (1951: 446) considered all of the bitterns of the genus *Botaurus* (including the Australian *poiciloptilus*, the nearctic *lentiginosus* and the neotropical *pinnatus*) as conspecific with the palearctic *stellaris*. This is certainly carrying "lumping" to an unwarranted extreme. The North American Bittern differs from *stellaris* in many important particulars, including courtship patterns, voice, type of plumes, proportions, color pattern, etc. Some members of the family Ardeidae which are currently placed in separate genera actually appear to be more closely related to one another than are *Botaurus stellaris* and *B. lentiginosus*.

After careful examination of the series of bitterns in several museums, I have found no reason to justify recognition of the proposed western subspecies, *B. l. peeti* Brodkorb. The supposed difference in tarsal measurements between eastern and western birds does not hold good. There is much color variation, sex for sex, in this species, but I fail to find any geographic correlation. Certain specimens in the U. S. National Museum have been identified as "*peeti*" or "*lentiginosus*", apparently by appearance alone and without regard to distribution. This has resulted in a rather anomalous geographic arrangement, since some Florida specimens have been labeled "*peeti*" and some Baja California specimens "*lentiginosus*". In short, I can not agree with a recent statement that "western populations are different on average characteristics from eastern populations, thus validating *peeti* as a distinct subspecies" (Jewett and others, 1953: 96).

7. The genus *Plegadis*

The White-faced Glossy Ibis has long been troublesome both from nomenclatorial and taxonomic viewpoints. It was known for years as *Plegadis guarauna*, but Hellmayr and Conover (1942: 301, footnote) showed that the name *Scolopax guarauna* Linnaeus is properly applied to the Limpkin (*Aramus*). The name then reverted to *Plegadis mexicanus*. In a later volume, however, Hellmayr and Conover (1948: 265, footnote) indicated their belief that *Tantalus mexicanus* Gmelin is so poorly described as to be unidentifiable. They therefore turned to the next available name, *Numenius chihi* Vieillot, which I shall use here.

With few exceptions (cf. Amadon and Woolfenden, 1952: 2), the two forms of Glossy Ibis in North America are listed by most authors as two full species. Both are commonly supposed to breed in Louisiana, but Lowery (1947: 181-182) has shown that *falcinellus* is rare in that state, at least at the present time, and its breeding there seems to be discredited.

The two Glossy Ibises are also listed (Hellmayr and Conover, 1948: 265, 266, 269) as breeding sympatrically in Florida. The breeding specimen of *chihi* from Lake Washington reported by Brewster (1886) remains the only record from the state (Howell, 1932: 117). It is, however, a definite breeding record, based on a female taken with a set of eggs. I have examined the

specimen (through the courtesy of Raymond A. Paynter, Jr., of the Museum of Comparative Zoölogy), and it appears to be a perfectly typical example of *chihi*. This is the only record known to me of either Glossy Ibis breeding within the range of the other; the thought is inescapable that this single record is insufficient evidence upon which to base statements that the breeding ranges of the two forms overlap and that therefore they must represent two species. Both forms of Glossy Ibis are notorious wanderers, and have been taken in localities far from their normal ranges. If *chihi* can wander as far as western New York, as it has upon at least two occasions, it is certainly not inconceivable that a female of this form may have wandered to Florida and remained to breed in a colony of *falcinellus*. It happens that we have definite evidence that these two ibises are completely interfertile. An editorial note which appeared, appropriately enough, in *The Ibis* (1905: 294) mentions the fact that two flocks in the London Zoo, *chihi* from Argentina and *falcinellus* from Spain, freely interbred for many years. There seems to be no good reason why the two forms should not be considered conspecific, the White-faced Glossy Ibis to be known as *Plegadis falcinellus chihi* (Vieillot).

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Cornell University, Ithaca, N. Y.

Manitoba Museum, Winnipeg, Manitoba.

Minnesota Museum of Natural History, Minneapolis, Minn.

Museum of Comparative Zoölogy, Cambridge, Mass.

Museum of Vertebrate Zoology, Berkeley, Calif.

Museum of Zoology, University of Michigan, Ann Arbor, Mich.

National Museum of Canada, Ottawa, Ontario.

New York State Museum, Albany, N. Y.

Philadelphia Academy of Natural Sciences, Philadelphia, Pa.

Rochester Museum of Arts and Sciences, Rochester, N. Y.

Royal Ontario Museum of Zoology and Palaeontology, Toronto, Ontario.

Teachers College, Fredericton, New Brunswick.

United States Fish and Wildlife Service, Washington, D.C.

United States National Museum, Washington, D.C.

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Certain individuals other than staff members of the institutions listed above have been particularly helpful in gathering specimens or information for me, or in throwing light on particular problems. Thanks are especially due to the following: Heman P. Adams, Kile R. Barbehenn, Allen H. Benton, Frances L. Burnett, F. Graham Cooch, Robert W. Dickerman, William C. Dilger, Stephen W. Eaton, Ernest P. Edwards, Eugene Eisenmann, Richard B. Fischer, Winfred N. Ford, Jr., Robert Goodwin, Karl Haller, Paul M. Kelsey, Brina Kessel, Daniel Marien, Paul S. Martin, Marjorie Crimmings McBride, Harry C. Oberholser, Allan R. Phillips, Edgar M. Reilly, Jr., C. Richard Robins, Louie Wilson Schubert, Robert C. Van Etten and Glen Woolfenden.

The original research upon which this series of papers is based was carried out under the direction of Professors Arthur A. Allen, Robert T. Clausen and Edward C. Raney, of Cornell University. I am indebted to them for their interest and guidance.

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ART. 19. PLANTS FROM LOWER SEAL LAKE, UNGAVA, CANADA

BY DOROTHY L. PEARTH

Assistant Curator of Plants, Carnegie Museum

Clearwater Explorations, Ltd., conducted geological and biological studies in Ungava in the summer of 1953. Through the kindness of R. D. Cowen, of Cleveland, Ohio, and J. V. Rawson, of Plainfield, N. J., Dr. J. Kenneth Doult, Curator of Mammals, Carnegie Museum, was included in the party as mammalogist. Dr. Doult's report "Observations on Mammals along the East Coast of Hudson Bay and the Interior of Ungava," including the itinerary of the expedition, has already appeared (Annals of the Carnegie Museum, volume 33, pages 235-249).

While at Lower Seal Lake in August, 1953, Dr. Doult took occasion to collect plants of the area in addition to mammals. The notes in quotation marks and the Indian names of the plants were supplied by him; and his collector's numbers, when indicated, are in parentheses. The plants are listed in phylogenetic order, under two different localities.

Lower Seal Lake, Ungava, 56°31' N. 73°48' W., August 9-14, 1953

EQUISETACEAE

Equisetum sylvaticum Linnaeus. Wood horsetail. (7449.)

"Found only in protected places; these were along a brook under dense spruce and tamarack."

LYCOPODIACEAE

Lycopodium annotinum var. *pungens* (LaPylaie) Desvaux. Stiff or bristly club-moss variety. (7444b.)

PINACEAE

Larix laricina (DuRoi) K. Koch. Tamarack or larch; Indian name, Napash-ook. (7442.)

"Largest tree seen was 42 feet high and at two feet above the ground was 11 inches in diameter."

GRAMINEAE

Calamagrostis canadensis var. *robusta* Vasey. Variety of blue-joint grass. (7437.)

Agrostis borealis Hartman. Northern bentgrass. (7446.)

CYPERACEAE

Carex bigelowii Torrey. Bigelow sedge. (7448.)

SALICACEAE

Salix cordifolia var. *callicarpaea* (Trautvetter) Fernald. Variety of heart-leaved willow; Indian name, Nip-shee. (7477.)

CORYLACEAE

Betula glandulosa Michaux. Dwarf birch; Indian name, Nee pee. (7478.)

Alnus crispa var. *mollis* Fernald. Variety of green or mountain alder. (7453.)

"Three to four feet high. Common in protected places along shores or old beaches."

ROSACEAE

Potentilla tridentata Aiton. Three-toothed cinquefoil. (7435a.)

Potentilla palustris (Linnaeus) Scopoli. Marsh five-finger. (7441.)

EMPETRACEAE

Empetrum nigrum Linnaeus. Black crowberry; Indian name, Me-nik sho. (7443.)

VIOLACEAE

Viola adunca var. *minor* (Hooker) Fernald. Variety of the hooked violet. (7444a.)

ONAGRACEAE

Epilobium augustifolium Linnaeus. Fireweed or great willow-herb. (7447.)

CORNACEAE

Cornus canadensis Linnaeus. Dwarf cornel or bunchberry. (7435c.)

PYROLACEAE

Pyrola minor Linnaeus. Smaller shinleaf. (7438.)

ERICACEAE

Ledum palustre var. *decumbens* Aiton. Variety of narrow-leaved Labrador tea. (7451-7452.) Specimen in fruit.

"In flower at Clearwater Lake, July 28."

Vaccinium uliginosum var. *alpinum* f. *langeanum* (Malte) Polunin. Alpine bilberry form. (7450a.) Specimen with ripe fruit.

"July 28, at Clearwater Lake, only green berries were seen. First ripe berries were seen August 8."

V. vitis-idaea var. *minus* Loddiges. Mountain cranberry or cowberry. (7450b.)

SCROPHULARIACEAE

Euphrasia arctica Lange. Arctic eyebright. (7444c.)

Pedicularis labradorica Wirsing. Lousewort. (7435b.)

CAPRIFOLIACEAE

Linnaea borealis var. *americana* (Forbes) Rehder. American twinflower. (7439.)

Viburnum edule (Michaux) Rafinesque. Mooseberry. (7454.)

COMPOSITAE

Aster puniceus var. *firmus* (Nees) Torrey and Gray. Variety of the purple-stem aster. (7440.)

Lower Seal Lake, Ungava, Camp 2, 56°34' N. 73°35' W., August 16, 1953

PINACEAE

Picea mariana (Miller) Britton, Sterns and Poggenberg. Black spruce; Indian name, Che-tak-win. (7491.)

"Most common tree, but becoming scattered and scraggly here."

CARYOPHYLLACEAE

Arenaria groenlandica (Retzius) Sprengel. Mountain sandwort.

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ART. 20. ORCHIDS OF WESTERN PENNSYLVANIA

BY L. K. HENRY* AND W. E. BUKER†

To the plant collector or outdoor botanist, the Orchidaceae is a fascinating family, for a number of reasons. One recalls, of course, the beautiful greenhouse tropical orchids that make up milady's corsage. Our temperate zone orchids are relatively inconspicuous; they are not common, and they have a tantalizing habit of being here today and gone tomorrow, for quite a few species bloom sporadically and a few even spend almost all of their lives underground. Then, too, there is the difficulty, almost insurmountable, that gardeners have encountered on trying to grow them outdoors. Very few are amenable to cultivation under ordinary conditions—and indeed they should not be collected for that purpose. Further, the beauty of some of our native species and the inconspicuousness of others adds to their interest. So, sooner or later, the outdoor naturalist is quite likely to become a victim of "orchiditis." We admit to a bad case.

There is no shortage of good recent books or articles dealing, wholly or in part, with the orchids. We mention the following with acknowledgment of the help we have received from them: D. S. Correll, "Native Orchids of North America" (Chronica Botanica Co., Waltham, Mass., 1950); Frank Morris and Edward A. Eames, "Our Wild Orchids" (Scribner, 1929); Jean E. Wallace, "The Orchids of Maine" (University of Maine Bull., v. 53, no. 12, 1951); P. D. Strausbaugh and Earl L. Core, "Flora of West Virginia," pt. 1 (West Virginia University Bull., series 52, no. 12-2, 1952); M. L. Fernald, "Gray's Manual of Botany," ed. 8 (American Book Co., 1950); E. T. Wherry, "Notable Pennsylvania Orchids" (Proceedings of the Pennsylvania Academy of Science, v. 12, p. 42-45, 1938); O. E. Jennings and Andrey Avinoff, "Wild Flowers of Western Pennsylvania and the Upper Ohio Basin" (University of Pittsburgh Press, 1953); Henry A. Gleason, "The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada," v. 1 (New York Botanical Garden, 1952).

We are limiting our discussion to western Pennsylvania (that is, west of the eastern borders of Potter, Clinton, Centre, Huntingdon, and Fulton counties) because (1) the divisions of the state west and east of the mountains constitute somewhat diverse floral regions; (2) the eastern part of the state has been studied more intensively by Philadelphia botanists; (3) western Pennsylvania is the part with which we are most familiar; and (4) we have been impressed by the fact that western Pennsylvania has been a sort of *terra incognita* in botanical manuals dealing with flora of eastern North America.

There has been no lack of collecting in western Pennsylvania. Collectors active in the past, to mention only a few, were B. H. Patterson, John A. Shafer, John Bright, and Dr. O. E. Jennings. Considering transportation limitations under which they worked, these men (and others) did an

* Curator of Plants, Carnegie Museum.

† Research Associate, Carnegie Museum.



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excellent job of covering their territory. Some of their earlier collections can not now be duplicated. More recently, with easier accessibility to more remote areas, and increased interest in collecting, quite a few new discoveries have been made.

Starting about 1944, a group of men, comprising, variously, Frederick H. Beer, A. J. Deer, Max Henrici, D. H. Krouse, and the present authors, have collected rather intensively in the western end of the state, for Carnegie Museum. Making at least one trip each week during the collecting season, we have added considerably to the knowledge of the botany of our area. We have been privileged, too, to meet several times with Dr. David Berkeheimer of Reading, whose knowledge of the botanical rarities of Bedford County is unrivaled. We have also had the pleasure of making several joint trips with Dr. E. T. Wherry of the University of Pennsylvania in Philadelphia.

Various persons have shown us, or aided us in finding, rare orchids. On our trip of June 29, 1946, to the Mt. Davis Bog, we were led by the late Dr. Harned, author of "Wild Flowers of the Alleghanies." Mrs. Harriet Burkhardt, of Canadohta Lake, led us to the calcareous bogs in Erie County where we found the showy lady's-slipper still abundant, and several other rare orchids. Clay Gifford, of Waynesburg, showed us our first puttyroot. Richard Crist, of Somerset, an excellent painter of wild flowers, has helped us in our search for *Listera*.

The Orchidaceae is a huge family, the largest of the monocotyledons, exceeded in number of species only by the Compositae, a dicotyledonous family. The family is considered to have developed from the Liliaceae, and to represent the highest development among the Monocotyledoneae. The greatest concentration of orchids is in the tropics, the temperate orchids representing rather outlying and usually less spectacular members of the family.

While western Pennsylvania would not be considered outstanding for its wealth of orchids (compared with, say, the Pine Barrens of New Jersey), we nevertheless have a respectable representation. Gray's Manual lists 21 genera and 77 species for the northeastern states and adjacent Canada. We have specimens from western Pennsylvania of 15 genera and 46 species. This compares not unfavorably with Maine (15 genera, 46 species) and West Virginia (16 genera, 36 species).

For less common species we have given locality and date of collection.

Opinions are bound to differ, of course, as to which are the most beautiful and interesting orchids of western Pennsylvania. We sent a questionnaire to six persons whom we knew to be quite familiar with all our wild orchids, and asked them to list their favorite ones. Tabulating the replies, we found that their favorites were, in order of preference:

1. Showy lady's-slipper (*Cypripedium reginae*)
2. Dragon's-mouth (*Arethusa bulbosa*)
3. Pink lady's-slipper (*Cypripedium acaule*)
4. Showy orchis (*Orchis spectabilis*)
5. Grass-pink (*Calopogon pulchellus*)

Also mentioned by at least one person were the following, still in order of preference:

6. Large purple-fringed orchid (*Habenaria psycodes* var. *grandiflora*)
7. Small yellow lady's-slipper (*Cypripedium Calceolus* var. *parviflorum*)
8. Rose pogonia (*Pogonia ophioglossoides*)
9. Round-leaved orchid (*Habenaria orbiculata*)
10. Purple fringeless orchid (*Habenaria peramoena*)
11. Yellow-fringed orchid (*Habenaria ciliaris*)
12. White adder's-mouth (*Malaxis monophyllos* var. *brachypoda*)

Which orchids are most common in western Pennsylvania? It depends upon the part to which you refer, since the flora of the glaciated northern part differs considerably from that of the southwestern part and from the mountainous districts. In the Pittsburgh area, we would list the most common orchids as follows:

1. Nodding ladies'-tresses (*Spiranthes cernua*)
2. Green-fringed orchid (*Habenaria lacera*)
3. Round-leaved orchid (*Habenaria orbiculata*)
4. Downy rattlesnake-plantain (*Goodyera pubescens*)
5. Pink lady's-slipper (*Cypripedium acaule*)

Where are the most interesting habitats for orchids in western Pennsylvania? Several of our prettiest orchids are bog species, but there are no true bogs in western Pennsylvania south of the glaciated areas, except in the mountains. The Mt. Davis Bog, near the highest point in Pennsylvania, in Somerset County, harbors an abundance of rose pogonia and grass-pink, as well as a few plants of the heart-leaved twayblade around its edges. Along U. S. Route 40, on the plateau east of Uniontown, is a particularly rich area. In the Markleysburg Bog is quite a concentration of rose pogonia and grass-pink. In drier ground near the bog grow the yellow-fringed orchid, green adder's-mouth, small green wood orchid, and an occasional green-fringed orchid. In this general area grows also the purple fringeless orchid, and near-by is our only Pennsylvania station for *Arethusa*.

The Sulphur Springs Bog, an acid-reaction bog near Columbus, Warren County, has two orchids not found at present anywhere else in our region—the white-fringed orchid and the southern twayblade. It displays these orchids in a charming setting, as is well shown in a plant habitat group in Carnegie Museum.

Not far away, near Union City in Erie County, is a bog we found only in 1949, which is perhaps the most interesting in western Pennsylvania. It is a sphagnum-tamarack bog, apparently much like the Sulphur Springs Bog, but the reaction is alkaline, and the plants are consequently different. Here, in a small area, we found showy lady's-slipper in abundance, green-flowered bog orchid, tall white bog orchid, hybrid northern bog orchid, white adder's-mouth, and Loisel's twayblade—all quite rare in western Pennsylvania.

Particularly tantalizing, and offering opportunities for further field work, are the orchids which have not been found here, but which we hope to find. We did not see *Aplectrum* (puttyroot) in bloom until 1953, and we know of only one station for *Arethusa*. Long-bracted green orchid, crane-fly, three

birds, and Wister's coral-root have never been found by us, but we believe that any of these may be found in our area; and there is always an outside chance that we may stumble upon outposts of still others, mentioned in our description of the species but not found as yet.

Perhaps it is just as well that we have not found them all; we will have an excuse for starting out again when the collecting season rolls around once more. This article is based upon orchids in the Carnegie Museum Herbarium. The initials used in the collection data are to be interpreted as follows: O.E.J., O. E. Jennings; L.K.H., L. K. Henry; W.E.B., W. E. Buker; J.A.S., J. A. Shafer.

Field work for this, and other local botanical studies, has been sponsored in part by the Rockledge Garden Club, of Pittsburgh, whose annual gifts for this purpose have contributed greatly to increased knowledge of the plants of western Pennsylvania. We are indebted to Mrs. Dorothy L. Pearth, Assistant Curator of Plants, for the fine drawings, made so far as possible from living specimens. Publication of these as illustrations in this paper was made possible through the generosity of Mr. and Mrs. A. W. Robertson, of Pittsburgh, to whom we are most grateful also.

Figures are of natural size except where reductions (shown with the figure) or enlargements (given in the title) are indicated.

KEY TO THE GENERA OF ORCHIDS OF WESTERN PENNSYLVANIA

Inflorescence racemose or spike-like, bearing 2 or more flowers.

Flowers spurred; spur over 2 mm. long.

Leaves 2, basal.

Leaves fleshy, oblong ovate; flowers pink and white, appearing in May or June *Orchis*.

Leaves not fleshy, nearly orbicular; flowers greenish-yellow or greenish-white, appearing in July or August *Habenaria*.

Leaves all cauline: flowers monocolored *Habenaria*.

Flowers not spurred, or with spur less than 2 mm. long.

Leaves single or absent.

Leaves absent, reduced to scale-like sheaths; plant yellowish-brown *Corallorhiza*.

Leaves absent at flowering time; scape bearing raceme of dull yellow-brown purplish flowers *Aplectrum*.

Leaf present at flowering time.

Leaf ovate; flowers greenish-white, tiny *Malaxis*.

Leaf linear; flowers magenta or pink *Calopogon*.

Leaves more than one.

Leaves two; flowers madder-purple or yellowish-green.

Leaves opposite, sessile, near the middle of the stem *Listera*.

Leaves basal *Liparis*.

Leaves more than two; flowers white.

Leaves in basal rosette, conspicuously white-veined *Goodyera*.

Leaves all near the base, green without white markings; flowers in one-sided spiral racemes *Spiranthes*.

- Leaves more than two; flowers purplish-green *Epipactis*.
- Inflorescence not racemose; flowers borne singly in axils of leaves, or 1 or 2 at summit of a scape.
- Lip inflated, moccasin-shaped *Cypripedium*.
- Lip not inflated, bearded.
- Leaf single.
- Leaf basal, seldom present at flowering time; flower single, magenta *Arethusa*.
- Leaf lance-oval, midway on stem; present at flowering time; flowers solitary, rarely 2, pale to deep pink*Pogonia*.
- Leaves 5 or 6, sessile and whorled, near apex of stem; flowers solitary or 2 on a pedicel, bright yellowish-green *Isotria*.

Cypripedium Linnaeus. Lady's-slipper

The lady's-slippers are doubtless our most spectacular and most familiar orchids, and have suffered most from picking by herb collectors and would-be gardeners. The generic name means "Venus's shoe," from the inflated lip. Of the five species and three varieties of *Cypripedium* listed in Gray's Manual, we have four, with the small white lady's-slipper (*C. candidum*) considered a rather remote possibility. Only the ram's-head (*C. arietinum*) is out of our range, getting no closer than central New York. The pink and the large yellow are reasonably common; the showy and the small yellow are limited to a few bogs in the northern part of our area; and the small white has not been found here at all. Lady's-slippers offer little taxonomic difficulty, with the exception of the large yellow and the small yellow.

KEY TO SPECIES OF CYPRIPEDIUM

- Stem elongated, leafy to the top; flowers 1 or 2.
- Lip golden yellow, wax-like, rounded at apex; sepals and lateral petals lanceolate, longer than the lip.
- Sepals and lateral petals usually madder-purple; the petals tightly spiral-twisted, 3.5-5 cm. long; chiefly of bogs and swamps1. *C. Calceolus* var. *parviflorum*.
- Sepals and lateral petals usually greenish-yellow, often streaked with purple; the petals loosely spiraled, 5-9 cm. long; chiefly of meso-phytic woods2. *C. Calceolus* var. *pubescens*.
- Lip white with purple stripes; sepals and lateral petals greenish-yellow, longer than the lip3. *C. candidum*.
- Lip white or suffused with pink or purplish; sepals and lateral petals white, long oval, shorter than the lip4. *C. reginae*.
- Stem short, scapose with 2 basal leaves, lip pink, bag-like, fissured from the front5. *C. acaule*.

1. *C. Calceolus* var. *parviflorum* (Salisbury) Fernald. Small yellow lady's-slipper.

The varietal name means "small-flowered." The taxonomic status of this and the following variety is very much confused. Of four recent works treating the orchids, no two agree on the yellow lady's-slippers. Correll

considers them one polymorphic variety of the European *C. Calceolus* Linnaeus; Fernald considers them separate varieties of *C. Caleolus*; Wherry regards them as four ecological entities; while Strausbaugh and Core treat them as separate species.

As understood by us, the small yellow lady's-slipper is quite rare in western Pennsylvania—found only in a few bogs in the glaciated areas, with a few stations in the mountains. It blooms in May or June, later than the large yellow. We found this variety growing in a marl bog along the railroad tracks from the Blair Bridge Road to Hartstown, Pymatuning Swamp, Crawford County, on June 2, 1951, and also in the Benson Swamp, Warren County, May 7, 1952.

We have several specimens from the Hartstown and Linesville sections of Pymatuning Swamp, and one from Chestnut Ridge, east of Hillside, Westmoreland County, the latter collected by Dr. Jennings, May 20, 1922.

2. *C. Calceolus* var. *pubescens* (Willdenow) Correll. Large yellow lady's-slipper. Fig. 1.

The varietal name means "hairy," and refers to the glandular hairs covering the leaves and stem. Once, probably fairly common in mesophytic woods, but now rather rare, due to picking and to clearing of the forests. It blooms from April to early June and is considered the easiest, of a difficult group, to cultivate in the garden. Small or immature specimens in herbaria might be mistaken for the preceding variety.

We have it from Allegheny, Beaver, Bedford, Centre, Clearfield, Crawford, Erie, Fayette, Huntingdon, Venango, Warren, and Westmoreland counties, and have seen it growing along Buffalo Creek on the Armstrong-Butler county line.

3. *C. candidum* Muhlenberg. Small white lady's-slipper.

The specific name means "white," referring to the color of the lip. This species has never, to our knowledge, been collected in western Pennsylvania, but is a distinct possibility. It has been found in eastern Pennsylvania, west-central New York, and in Portage County, Ohio. It is said to be a plant of open marl bogs and should be sought in the open bogs of the glaciated northwestern part of the state during May and June.

4. *C. reginae* Walter. Showy lady's-slipper. Fig. 2.

The specific name means "of the queen," suggesting the beauty of the flower. Although there are old records in the Herbarium from Beaver, Butler, Huntingdon, and Lawrence counties, it is now probably confined to Crawford and Erie counties. It grows in quite wet situations, apparently in bogs which are calcareous or neutral, and it blooms in June. Specimens in the Herbarium are as follows:

Crawford County: Pymatuning Swamp, Hartstown section, several collections obtained from 1908 to 1942 by O. E. Jennings. Beaver County: no locality, about 1885, J. F. Mansfield. Butler County: Slippery Rock, June 23, 1925, O.E.J. Erie County: northeastern part, June 18, 1925, Mrs. Anna Fernald; 2 mi. E. of Union City, June 18, 1949, W.E.B.; 4 mi. NE. of Union



FIG. 1. *Cypridium Calceolus* var. *pubescens*



FIG. 2. *Cypripedium reginae*

City, June 29, 1949, L.K.H., W.E.B. Lawrence County: Plaingrove Township Bog, June 30, 1917, John Bright.

5. *C. acaule* Aiton. Pink lady's-slipper. Fig. 3.

The specific name means "stemless," the plant having a very short, underground stem, with the flower at the end of a long, naked peduncle. This is our most common lady's-slipper. It grows in two kinds of habitats in our area—dry, acid woods, often under hemlocks, in the southern part, and on margins of bogs in the northern part. This species is very abundant in certain locations in the Raccoon Creek region of Beaver County and around Sulphur Springs Bog, near Columbus, in Warren County. The bog type in the north is distinctly smaller than the dry-soil type of the south. We have seen plants with twin flowers on a stem, and also an albino, along Route 8 north of Hydetown in Crawford County. It blooms from May into June.

We have it from all of western Pennsylvania except Cambria, Cameron, Indiana, McKean, and Potter counties. Additional collecting will probably reveal its presence in these counties.



FIG. 3. *Cypripedium acaule*
FLOWER

Orchis Linnaeus. Orchis

The generic name, the type of the family Orchidaceae, refers to the two small tubers at the base of some species. This genus has over thirty species in Europe, but only three in North America, one of which is Alaskan. One of the remaining two, the showy orchis, is widespread but rather uncommon in our region, while the other, the small round-leaved orchis, is chiefly Canadian, with only a limited range in the United States.

O. spectabilis Linnaeus. Showy orchis. Fig. 4.

The specific name means "showy." This attractive little plant is one of our earliest, blooming from early May into June. The leaves look somewhat like those of the large round-leaved orchid, but they are smaller, shinier, and more oblong-ovate. In our area it grows in the rich soil of deciduous woods and is widely distributed, but not common. It appears to like the mountainous regions, there being few records of it in our southwestern section. The finest stand we know is near Cucumber Falls, Ohiopyle, Fayette County.

Our collections show that this species is scattered through the following counties: Allegheny, Armstrong, Bedford, Butler, Cambria, Clarion, Crawford, Erie, Fayette, Indiana, Lawrence, Mercer, Venango, Washington, and Westmoreland.

Habenaria Willdenow. Rein orchid

The generic name refers to the shape of the lip, or spur, and means "rein" or "strap." Our region is particularly rich in Habenarias, as we have 15 of the 22 species listed in Gray's Manual. The rein orchids vary from rather nondescript, greenish-flowered species, such as *H. flava*, to the spectacularly showy fringed species, which are peculiar to eastern North America.

It is a polymorphic genus, and has been divided according to floral morphology into several genera by various botanists. Rydberg, for example, listed the fringed Habenarias (and *H. peramoena*) as *Blephariglottis*, the three round-leaved ones as *Lysias*, the northern bog orchids under *Limnorchis*, and *H. flava*, *clavellata*, and *viridis* var. *bracteata* each as separate genera. It appears that these numerous generic segregates form rather homogeneous groups, but to avoid possible confusion we prefer to follow the established custom as exemplified by Correll, Fernald, and others.

KEY TO SPECIES OF HABENARIA

Lip not fringed or three-parted.

Leaves cauline.

Lip with small lobes, basal or apical.

Spur shorter than lip, blunt saccate; floral bracts 2-4 times as long as the greenish flowers 1. *H. viridis* var. *bracteata*.

Spur longer than lip.

Leaves 1 or 2; flowers greenish-white; lip wedge-oblong 2. *H. clavellata*.

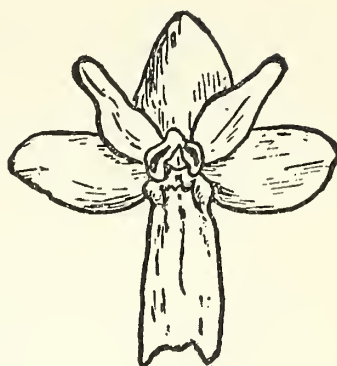
Leaves 3 or 4; flowers yellowish-white; lip quadrate-oblong; spike compact; plants stouter than in the species 3. *H. flava* var. *herbiola*.



FIG. 4. *Orchis spectabilis*

- Lip entire, strap-shaped, without lobes.
 Spur equaling, or shorter than, lip; sepals spreading.
 Flowers white; lip with dilated ovate base 4. *H. dilatata*.
- Flowers pale greenish-yellow.
 Lip lanceolate to oblong-ovate, not broadened at base 5. *H. hyperborea* var. *huronensis*.
 Lip with dilated or ovate base 6. \times *H. media*.
- Leaves basal.
 Scape naked or occasionally 1-bracted; flowers sessile, greenish-yellow, spur deflexed 7. *H. Hookeri*.
 Scape bracted mostly to summit; flowers pedicelled, greenish-white; spur horizontal, arching at tip.
 Spur 0.8-2.7 cm. long 8. *H. orbiculata*.
 Spur 3-4.5 cm. long 9. *H. macrophylla*.
- Lip simple and fringed.
 Flowers orange, lip broadly ovate, deeply fringed 10. *H. ciliaris*.
 Flowers white, lip tongue-shaped, fringed on margin 11. *H. blephariglottis*.
- Lip 3-parted and either fringed or toothed.
 Lobes of lip deeply lacerate-toothed.
 Petals narrow-oblong, entire; lip 1.5 cm. wide; spur as long as, or slightly longer than, the lip.
 Flowers yellowish-green to dirty yellow 12. *H. lacera*.
 Flowers purple to white, tinged with lavender 12. \times *H. Andrewsii*
 Petals fan-shaped, finely toothed; lip 2.5 cm. wide; spur much longer than the lip; flowers creamy-white to whitish green 13. *H. leucophaea*.
- Lobes of lip deeply lacerate-fringed; flowers lilac-pink to deep rose-purple.
 Lip less than 1.3 cm. wide with divisions fringed less than 1/3 of their length; raceme less than 3.5 cm. in diameter 14. *H. psycodes*.
 Lip more than 1.3 cm. wide, with divisions fringed more than 1/3 of their length; racemes more than 4 cm. in diameter 14. *H. psycodes* var. *grandiflora*.
 Lobes of lip irregularly eroded, the middle lobe deeply notched; flowers rose-purple to purple-violet 15. *H. peramoena*.
1. *H. viridis* var. *bracteata* (Muhlenberg) Gray. Long-bracted green orchid. Fig. 5.

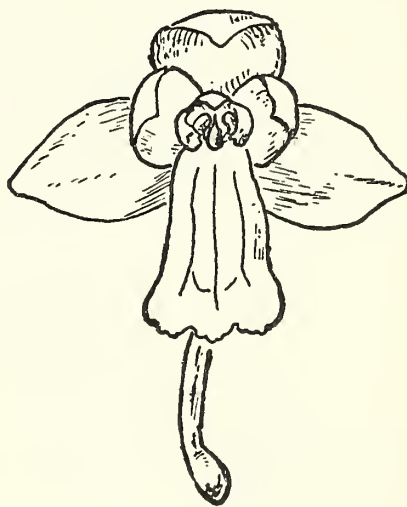
The specific name means "green," and the varietal name means "bracted," both appropriately describing the flower. This orchid is certainly rare in our region. We have an old record from Stoyestown, Somerset County (B. H.

FIG. 5. *Habenaria viridis* var. *bracteata*FLOWER $\times 8$ 

Patterson, 1887). The only recent record we know is that supplied by Dr. David Berkheimer of Reading, who, several years ago, found two plants at Grandview, in western Bedford County, near U. S. Route 30. When we looked for the plants in 1950, we were unable to find any.

It is a northern species and is likely to be found in our area at high altitudes. We saw it at Chittenango Falls, N. Y., growing near the bottom of a deep ravine in a limestone region and in bloom on July 19, 1949. It can be distinguished by the very long floral bracts and the large lower leaves.

2. *H. clavellata* (Michaux) Sprengel. Small green wood orchid. Fig. 6.

FIG. 6. *Habenaria clavellata*FLOWER $\times 4$ 

The specific name, meaning "like a little club," refers to the spur. This little, unshowy member of the orchid family is rather widely distributed in our area, growing prolifically where conditions suit it; otherwise, not at all. Suitable conditions seem to be found most often in the mountains, and in the bogs of the northern part of our region. It grows commonly on the plateau along U. S. Route 40 near Farmington southeast of Uniontown, Fayette County, under acid conditions. Most authorities indicate that the plant likes acid soil, but in the marl bog at Pymatuning Swamp it grows by the hundreds in the same situations as does the small yellow lady's-slipper, which is admittedly partial to calcareous conditions.

We have records from Allegheny, Bedford, Centre, Crawford, Erie, Fayette,

Fulton, McKean, Somerset, and Warren counties, with the greatest concentration in Fayette and Somerset.

3. *H. flava* var. *herbiola* (R. Brown) Ames & Correll. Pale green wood orchid. Fig. 7.

FIG. 7. *Habenaria flava* var. *herbiola*
FLOWER $\times 3$

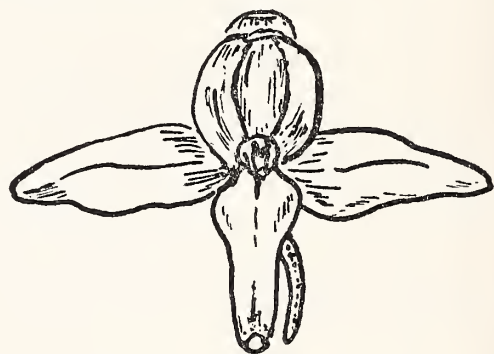


The specific name means "yellow," while the varietal name means "little plant," according to Correll, one of the authors of the varietal name. No more showy than the preceding, this orchid is less restricted to the mountainous and northern parts, and seems to prefer muddy ditches and ponds to real bogs. It, too, is widely distributed, but uncommon, and is an inconspicuous plant that is perhaps frequently overlooked. This variety is abundant beside a muddy ditch and in a swampy area near Patton's Point, Raccoon Creek, Beaver County. It blooms in June and July.

We have it from Beaver, Butler, Erie, Fayette, Fulton, Somerset, Warren, and Westmoreland counties.

4. *H. dilatata* (Pursh) Hooker. Tall white bog orchid. Fig. 8.

FIG. 8. *Habenaria dilatata*
FLOWER $\times 3$



The specific name means "dilated," describing the base of the lip. At a distance, these plants look somewhat like robust ladies'-tresses. We had only one locality record for the tall white bog orchid—Pymatuning Swamp, Crawford County (a specimen taken by Dr. Jennings in 1906 and one collected by W. R. Van Dersal in 1932)—until 1949 when, on June 29, we found the species plentiful in a couple of bogs near Union City and Wattsburg, Erie County. Both bogs are calcareous, and also harbor the green-flowered bog orchid, although in fewer numbers. These stations represent a southern limit in Pennsylvania for this northern species.

5. *H. hyperborea* var. *huronensis* (Nuttall) Farwell. Green-flowered bog orchid. Fig. 9.

FIG. 9. *Habenaria hyperborea* var. *huronensis*FLOWER $\times 2$ 

The specific name is appropriate here, for the range of this species is mostly "beyond the north" of our borders. The varietal name means "of Lake Huron." We had no records of this plant until June 19, 1948, when we found one in bud at the edge of Tamarack Swamp, Warren County. The following summer we found plants in bogs near Union City and at Wattsburg, Erie County. In both of the latter stations, it grew in company with the tall white bog orchid, though less plentifully. Where growing together, the green-flowered bog orchid did not grow out in the sphagnum of the open bog as did the white, but seemed to prefer less moisture and the shade of trees and bushes, such as were to be found around the bog margins. It is not showy, and at a distance resembles overgrown specimens of the pale green wood orchid. This is one of our rarest orchids, blooming in late June and July. We have it from the following locations:

Erie County: 4 mi. NE. of Union City, June 29, 1949, L.K.H., W.E.B.; 3.5 mi. SE. of Wattsburg, June 17, 1950, L.K.H., W.E.B. Warren County: bog 4 mi. NE. of Columbus, June 19, 1948, W.E.B.; 1 mi. S. of Spring Creek, Sept. 1, 1948, C. M. Boardman.

6. \times *H. media* (Rydberg) Niles. Hybrid northern bog orchid.

The specific name means "intermediate," its appearance being somewhat intermediate between its supposed parents, the two previously described species. We found a few plants of this hybrid in both of the Erie County bogs mentioned under *H. dilatata*.

7. *H. Hookeri* Torrey. Hooker's orchid. Fig. 10.

FIG 10. *Habenaria Hookeri*

FLOWER



This orchid was named in honor of Sir William Jackson Hooker, renowned English botanist, and is very rare in western Pennsylvania. There is an old record of it from Somerset County; Wherry reports it from Bedford Springs, Bedford County; and there are specimens in the Herbarium from Erie County (Presque Isle, 1879, and Northeast, 1894). On July 19, 1952, we collected a plant near Tamarack, Clinton County.

This is not a bog species, but grows commonly in fairly dry, open hardwood forests. We have seen it in such habitats in Maine, where it is much

more common. It is not too easily distinguished from the round-leaved orchid, which is found over much of our region.

In Hooker's orchid, the stem is ordinarily bractless, and the spur tapers to the tip; while in the round-leaved orchid, the stem usually has one to five bracts, and the spur is thickened toward the apex. The leaves in Hooker's are smaller and tend to be oblong rather than round.

8. *H. orbiculata* (Pursh) Torrey. Round-leaved orchid. Fig. 11.

The specific name means "round," referring to the shape of the leaves. This is one of our most common orchids, never very abundant but occurring over most of our area in dry or moist spots in coniferous, hardwood, or mixed forests. This species is more southern in its wide distribution than is Hooker's, and is found as frequently in the southwestern counties as anywhere. The flowers are not showy, but the large shiny round leaves, lying flat on the ground, are unusual and interesting. Superficially, it resembles Hooker's orchid, but is much more common, and it blooms in July and August.

Scattered through Allegheny, Armstrong, Beaver, Bedford, Butler, Crawford, Erie, Fayette, Forest, Huntingdon, Jefferson, Mercer, Somerset, Venango, and Westmoreland counties.

9. *H. macrophylla* Goldie. Large round-leaved orchid.

The specific name means "large-leaved." Botanists are in dispute as to whether this is a good species or simply a round-leaved orchid with exceptionally large leaves and elongate spurs. We have a plant collected by James Murray near Cambridge Springs, Crawford County, July 15, 1928, and one by John Bright, vicinity of Somerset, July 1, 1924. Both are so gigantic that we are here accepting them as a separate species. It should be sought again in our region.

10. *H. ciliaris* (Linnaeus) R. Brown. Yellow-fringed orchid. Fig. 12.

The specific name means "fringed," referring to the character of the lip. The yellow-fringed orchid occurs in our region mostly in Fayette County. It is common on the plateau east of Uniontown along U. S. Route 40, where it grows in the rather dry, sandy soil in open woods or thickets. Unlike the *Habenaria* discussed previously, this is one of the showiest of the genus, and the only orange-flowered one in our area. It is essentially southern in its distribution, and stays close to the southern border in western Pennsylvania, although its range extends farther north in the eastern part of the state. Farther south, it grows sometimes in bogs, but here we have never seen it in such locations. It is a husky plant, reaching two feet, and displaying large, showy blooms in July and August. If one must try orchids in the garden, this seems one of the most likely prospects.

We have it from two localities in Fayette County and one from each of the counties of Bedford, Centre, Somerset, and Westmoreland.

11. *H. blephariglottis* (Willdenow) Hooker. White-fringed orchid. Fig. 13.

The specific name means "eyebrow-tongued," from the fringed lip.

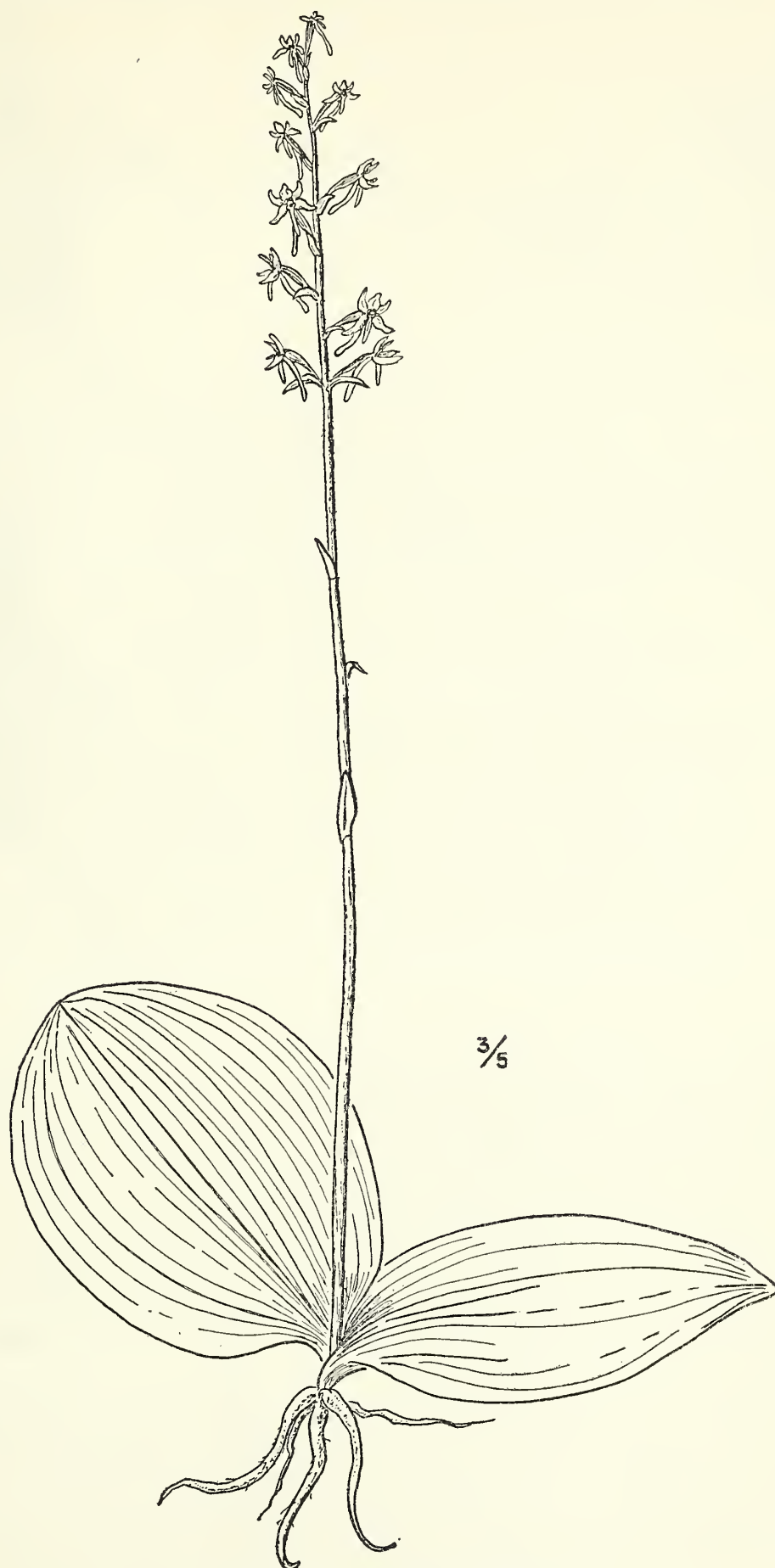
FIG. 11. *Habenaria orbiculata*

FIG. 12. *Habenaria ciliaris*
FLOWER $\times 2$

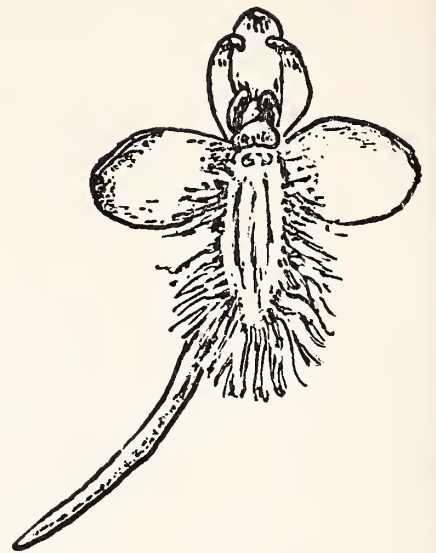


FIG. 13. *Habenaria blephariglottis*
FLOWER $\times 2$



Authorities claim that the yellow-fringed and white-fringed orchids are almost indistinguishable except for color; but that does not appear to be the case as they grow here. They occur at opposite borders of the state—the yellow-fringed in mountain woods and the white-fringed in sphagnum bogs, with the former several times as large as its white cousin. The white-fringed is known to grow in western Pennsylvania at present only in Sulphur Springs Bog, near Columbus, Warren County, although we have a 1934 record from Buck Swamp, Shanksville, Somerset County. The Warren County plants were in good bloom on July 24, 1948.

12. *H. lacera* (Michaux) Loddiges. Ragged, or green-fringed orchid. Fig. 14.

The specific name means "torn," or "shredded," referring to the deeply fringed lip. This, the least showy of our fringed *Habenarias*, is one of our most common orchids. It is widely distributed over western Pennsylvania, growing usually in moderately moist, grassy fields, and blooming in late summer. It is scattered over Allegheny, Armstrong, Beaver, Butler, Centre,

FIG. 14. *Habenaria lacera*FLOWER $\times 2$ 

Clinton, Crawford, Erie, Fayette, Indiana, Lawrence, Mercer, Somerset, Warren, and Westmoreland counties.

In some regions it hybridizes with the purple-fringed orchid, forming $\times H. Andrewsii$, but this hybrid must be rare here, since we have but one record (Buck Swamp "at Stoyestown," Somerset County, collected by B. H. Patterson, July 11, 1907). In fact, the green-fringed and the purple-fringed orchids do not appear to grow together much in our area.

13. *H. leucophaea* (Nuttall) Gray. Prairie white-fringed orchid.

The specific name means "whitish," describing the color of the flowers. It is perhaps optimistic to include this orchid in a list of plants which grow, or may possibly be found, in western Pennsylvania; but it has been found occasionally in west-central New York and in Ashtabula County, Ohio, so it does not seem utterly impossible that it might be found in some remote (or newly formed) sphagnum bog of Erie, Warren, or Crawford County. It is said to be a glorified form of the green-fringed orchid, but much larger, white-flowered, and fragrant, blooming mostly in June and July. It has much the same range and habitat as the small white lady's-slipper—another hoped-for possibility.

14. *H. psycodes* (Linnaeus) Sprengel. Purple-fringed orchid. Fig. 15.

The specific name means "butterfly-like." The purple-fringed orchids have always been puzzling to botanists. Very large specimens, with big flowers, lighter in color and blooming a bit earlier, have been separated as *H. fimbriata* (Aiton) R. Brown. Correll, in his recent book, makes this *H. psycodes* var. *grandiflora* (Bigelow) Gray (large purple-fringed orchid), with which we are in agreement. These showy orchids are rather common in the glaciated northern part of our area, from Butler County north. As we observe them in western Pennsylvania, we are unable to find any sharp line of demarcation between them; there are too many intermediates. The large form appears to be an ecological response to environment, usually growing in richer, moister soil, in deep shade. While, in other areas, two species may be involved, we prefer to consider the plants that grow here as one species.

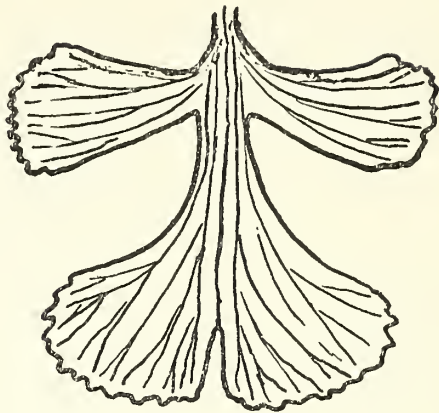
We have this species from Allegheny, Beaver, Bedford, Cambria, Crawford, Elk, Erie, Forest, Lawrence, McKean, Potter, Somerset, Venango, and Warren counties. The variety *grandiflora* is found in many of the same counties, and in the counties of Blair and Westmoreland as well.



FIG. 15. *Habenaria psycodes*

15. *H. peramoena* Gray. Purple fringeless orchid. Fig. 16.

FIG. 16. *Habenaria peramoena*
LIP PETAL $\times 2$



The specific name, meaning “very beautiful,” is appropriate, since this orchid with its great spike of dark rose is as showy as any. Its range in western Pennsylvania is apparently restricted to the south. We saw a dozen spikes along the shore of Deer Lake in Fayette County on August 2, 1947. The following summer, as is not unusual with the orchids, there were none. The plant, however, is not uncommon in Fayette and Somerset counties, and we also have it from Allegheny, Bedford, Cambria, and Westmoreland.

Listera R. Brown. Twayblade

The generic name commemorates Dr. Martin Lister, a famous English naturalist. These twayblades are small, inconspicuous plants, characterized by a pair of sessile, opposite leaves about half way up the stem. We have three species in western Pennsylvania, but each species is known from but a single county. All are bog plants. They all appear to have the habit—not rare in the Orchidaceae—of not flowering every year.

KEY TO SPECIES OF LISTERA

- Lip not dilated at summit, oblong or linear and deeply cleft into 2 linear segments.
- Lip not auricled at base, with a tooth on each side; rachis and pedicels glabrous1. *L. cordata*.
- Lip auricled at base without basal teeth; rachis and pedicels glandular2. *L. australis*.
- Lip with dilated, broadly wedge-shaped summit, not auricled at base; pedicels glabrous3. *L. Smallii*.
1. *L. cordata* (Linnaeus) R. Brown. Heart-leaved twayblade. Fig. 17 (Lip petal, Fig. 18).

The specific name means “heart-shaped,” referring to the shape of the leaves. The heart-leaved twayblade is rare in western Pennsylvania, our only collections being from the vicinity of Mt. Davis in Somerset County. All the plants we have seen were growing under rhododendron, in sphagnum or very near it, and were extremely difficult to see. We saw our first plants at the edge of the Mt. Davis Bog on June 24, 1950. We found only a half-dozen or so plants. Then, on May 24, 1952, we saw three plants beside a spring near the top of Mt. Davis; and, on that same day, one more plant in

FIG. 17. *Listera cordata*FIG. 18. *Listera cordata*
LIP PETAL $\times 4$ 

a mountain bog, also near the top of Mt. Davis. Since most descriptions specify a height of 6-25 cm. (maximum 30), our plants all appear to be dwarfs, being not more than 10 cm. tall.

There is an old specimen in the Herbarium from Bear Meadows, Centre County, collected by J. T. Rothrock in 1868. Nuttall, early in the last century, reported seeing it near Waterford, Erie County.

2. *L. australis* Lindley. Southern twayblade. Fig. 19.

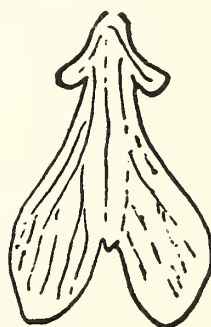
FIG. 19. *Listera australis*
LIP PETAL $\times 4$



The specific name means "southern," referring to the range of the plant. In our region, the southern twayblade is known only from the Sulphur Springs Bog, near Columbus, in Warren County. It grows plentifully in the sphagnum mat surrounding the pool, in exactly the same habitat as the white fringed orchid. The twayblade was in good bloom on June 18, 1950. As they grow in western Pennsylvania, the southern twayblade is considerably larger and more conspicuous than the heart-leaved.

3. *L. Smalli* Wiegand. Small's twayblade. Fig. 20.

FIG. 20. *Listera Smalli*
LIP PETAL $\times 4$



Named for John Kunkel Small, distinguished American botanist, this is another of the rare twayblades of western Pennsylvania. We have two specimens, both from Bear Meadows, Centre County—one collected by R. V. Mostoller, August 2, 1937, and one by A. J. Eames, June 18, 1931. This station is apparently the northern limit of its range. A water-color drawing by Richard Crist of a plant he collected near his home in Somerset fits this species, but, not realizing the importance of his find, he did not preserve the specimen; he has subsequently failed to find it again through several seasons.

Epipactis Swartz. Helleborine

The generic name is classical, having been used by Theophrastus for hellebore. North America has only one native species of *Epipactis*, the western giant helleborine. The other species found here is native to Europe and was apparently found first in North America near Syracuse, N. Y., in 1879. It has since spread rather widely, especially in the vicinity of the Great Lakes. When we first saw the plant in bud, we temporarily misidentified it as the long-bracted orchid.

E. Helleborine (Linnaeus) Crantz. Helleborine. Fig. 21.

The specific name means "like a hellebore." This is the only orchid introduced and naturalized in our area. It is still not common, since all of our records are from Warren and Erie counties. On July 7, 1951, we found half a dozen plants in bud on the wooded banks near the mouth of Elk Creek, west of Erie. Returning to the area in late summer, 1952, we found perhaps fifty plants along the banks of Elk Creek and along the shores of Lake Erie, where the species appears to be well established. The Herbarium has specimens from the following localities:

Erie County: Northeast, July 16, 1932, O.E.J.; 1 mi. NW. of Waterford, July 18, 1953, W.E.B. Warren County: North Warren, August 8, 1943, H. N. Moldenke.

Triphora Nuttall. Nodding-crest

The generic name means "three-bearing," referring to the fact that three flowers usually appear at a time. This genus is entirely American, with only one species ranging into our area. It is inconspicuous, or possibly absent, for we have never collected it. This orchid is said to be one of those species which seldom flower, spending most of its life underground.

T. trianthophora (Swartz) Rydberg. Three birds orchid.

The specific name means "bearing three flowers." Although this plant, also called nodding pogonia, has never been found in western Pennsylvania to our knowledge, it is a likely candidate, for it grows all around us. Our only Pennsylvania specimen is from Schuylkill County, but it occurs in West Virginia, New York, and in Ashtabula and Summit counties, Ohio. The plant is described as inconspicuous, blooming at infrequent intervals in August and September in the damp humus of hardwood forests.

Isotria Rafinesque. Whorled pogonia

The generic name means "with three equal parts," alluding to the three equal sepals. There are but two species in this genus, which is closely related to *Pogonia* and was once included under that name. From the foliage and odd flower, one would scarcely suppose it is closely related to the pretty little rose pogonia. When not in bloom, the plant might be mistaken for the much more common Indian cucumber (*Medeola*); but the stem is stouter, hollow, soft purple, and the leaves are usually in fives, while the leaves of *Medeola* are mostly in sixes. Both *Isotrias* are native to the eastern United States. The smaller whorled pogonia is a rare plant anywhere.

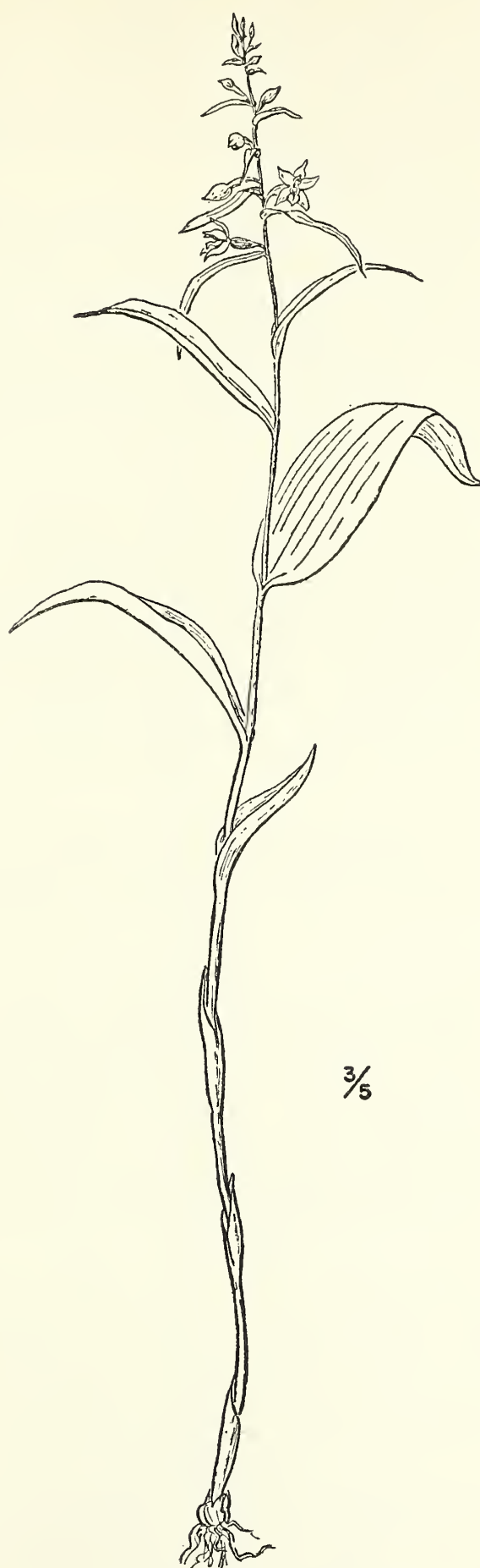


FIG. 21. *Epipactis helleborine*

KEY TO SPECIES OF ISOTRIA

- Flowering scape without leaves near base; involucre leaves soon spreading; flowers on long pedicels1. *I. verticillata*.
 Flowering scape with 2 small alternate leaves at base; involucre leaves soon reflexing; flowers subsessile2. *I. medeoloides*.

1. *I. verticillata* (Willdenow) Rafinesque. Whorled pogonia. Fig. 22.

The specific name means "whorled," referring to the arrangement of the leaves. The whorled pogonia occurs rather infrequently over southwestern Pennsylvania, in our records as far north as Venango County. In this region it seems to prefer dryish, open, rocky woods, blooming mostly in May.

We have specimens from various localities in Allegheny, Fayette, and Westmoreland counties, and one from Oil City in Venango County that was collected by B. H. Patterson in 1879.

2. *I. medeoloides* (Pursh) Rafinesque. Smaller whorled pogonia.

The specific name means "like a *Medeola*" [Indian cucumber genus]. This is one of the rarest orchids in eastern United States. One specimen only has been found in western Pennsylvania, near Rogersville, Greene County, by John Bright, May 24, 1922; but its range, from New Hampshire south to North Carolina and southeastern Missouri, is such that the possibility of finding it again ought to be kept in mind by collectors. It is described as a smaller edition of the whorled pogonia, with sessile and differently shaped flowers.

Pogonia Jussieu. Crest-lip

The generic name means "bearded," referring to the bearded lip. There are two species of *Pogonia*, one in eastern Asia and the other described below.

P. ophioglossoides (Linnaeus) Ker. Rose pogonia. Fig. 23.

The specific name means "like the adder's-tongue fern," from the similarity of the leaves. We have this pretty little orchid from Crawford, Erie, Fayette, Somerset, and Warren counties. The rose pogonia requires special conditions such as sopping, acid, sphagnum bogs, and where these conditions are met it is likely to be abundant. It is especially common in the Mt. Davis Bog, in Somerset County, and the Markleysburg Bog, in Fayette County. In our region it selects the wettest parts of open bogs, often growing with grass-pink.

Arethusa Linnaeus. Arethusa or dragon's mouth

The genus is named for the Greek river-nymph, Arethusa. This is another genus limited to eastern North America and eastern Asia (Japan). The root is a single corm that loosely embeds in acid sphagnum. As Fernald says, it is "rapidly becoming extinct south of Newfoundland and Canada."

A. bulbosa Linnaeus. Arethusa or dragon's mouth. Fig. 24.

The specific name describes the bulbous root. This is one of our favorites, and we were led a merry chase to find it. According to Correll's charming description, "it has the appearance of a fanciful little beast, with ears

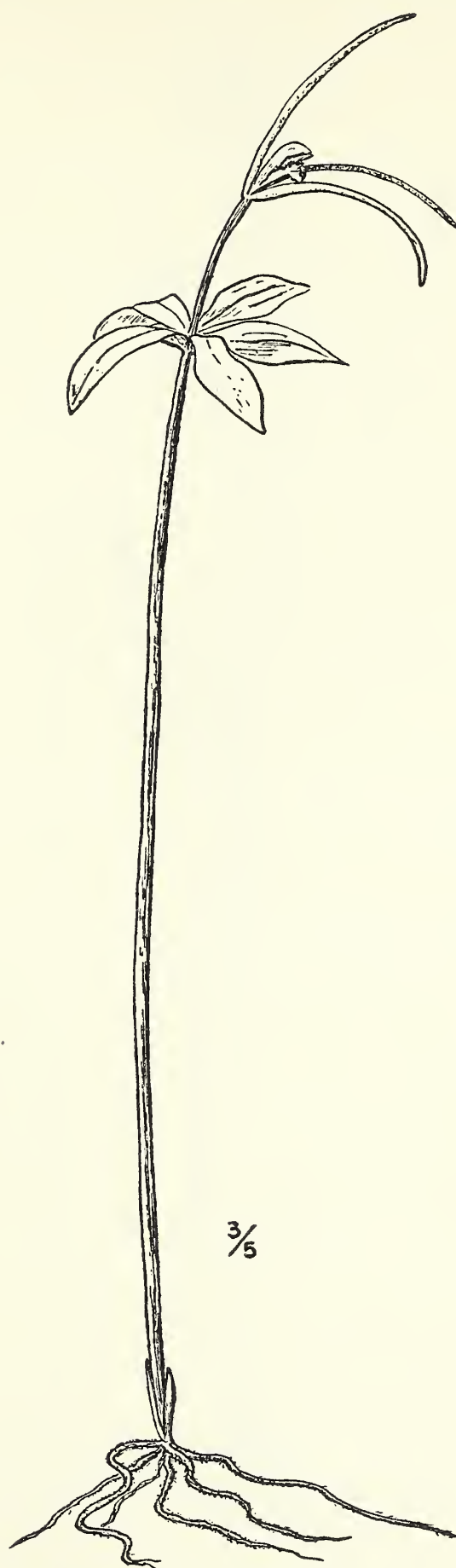


FIG. 22. *Isotria verticillata*



FIG. 23. *Pogonia ophioglossoides*

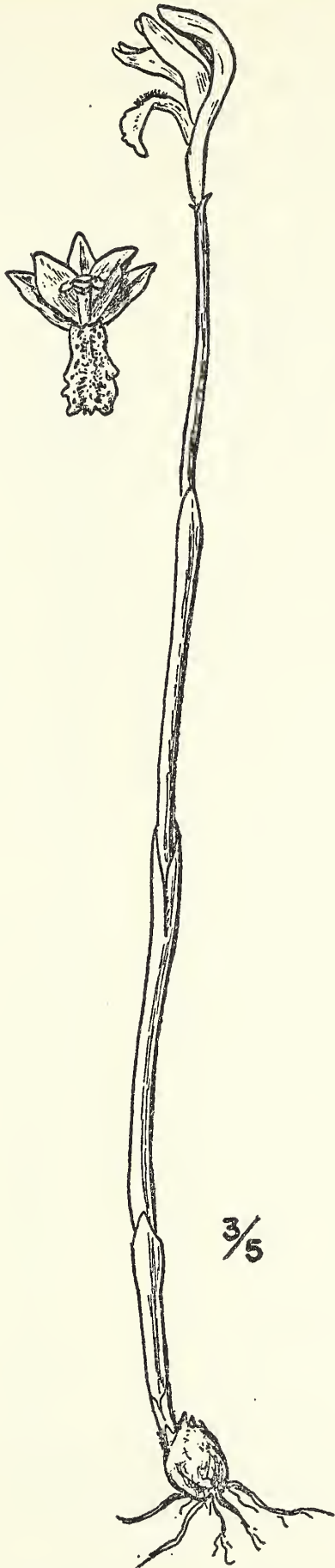


FIG. 24. *Arethusa bulbosa*

distended and lolling tongue, straining to recognize the intruder of its peaceful haunts." There are old records from Pymatuning Swamp (1924 and 1933) in Crawford County and from Presque Isle (1906), Erie County. After several years' search, we began to fear that it had become extinct in western Pennsylvania. Finally, however, on June 10, 1950, we found 10 plants in a mountain bog in Fayette County. Returning the following summer, we found only one plant in bloom; in 1953, none. This species may often be overlooked, for the blooming period is short and the plant is almost impossible to find when not in bloom.

Calopogon R. Brown. Grass-pink

The generic name means "beautiful beard," referring to the bearded lip. The common name is in reference to the grass-like leaves. There are four species of this genus in eastern North America, all but one in the southeastern United States. We have just one species in our region.

C. pulchellus (Salisbury) R. Brown. Grass-pink. Fig. 25.

The appropriate specific name means "little beauty." This charming orchid often grows with rose pogonia, and it would be difficult to find a prettier pair. The grass-pink evidently does not require conditions that are quite so wet as does the rose pogonia, and it is sometimes found out of strict bog conditions, in damp meadows. We know several locations where the grass-pink grows unaccompanied by rose pogonia; for example, in the Plain-grove Bog of Lawrence County. We have specimens from Butler, Centre, Crawford, Erie, Fayette, Lawrence, and Somerset counties, and Dr. Berkeheimer collected it in Bedford County.

Spiranthes Richard. Ladies'-tresses

Both the generic and the common name refer to the coiled flowers, having reminded someone of a girl's pigtails. The ladies'-tresses are divided naturally into two sections according to whether the flowers are single- or several-ranked. Of the 11 *Spiranthes* listed in Gray's Manual, we have five species and one variety. We have included two others as possibilities, since their ranges approach western Pennsylvania—one along our northern border and the other to the south. We are inclined to agree with Correll's observation that the ladies'-tresses are the most difficult to distinguish of all our orchids.

KEY TO SPECIES OF SPIRANTHES

Flowers in a single rank.

Leaves basal, ovate or elliptic.

Root a single finger-like tuber; leaves absent at flowering time (late July to September)1. *S. Grayi*.

Roots two to several finger-like tubers.

Leaves present at flowering time; spike one-sided or with few remote spirals; average flowering time, July to August2. *S. lacera*.

Leaves absent at flowering time; spike strongly spiraling; average flowering time, August to September3. *S. gracilis*.

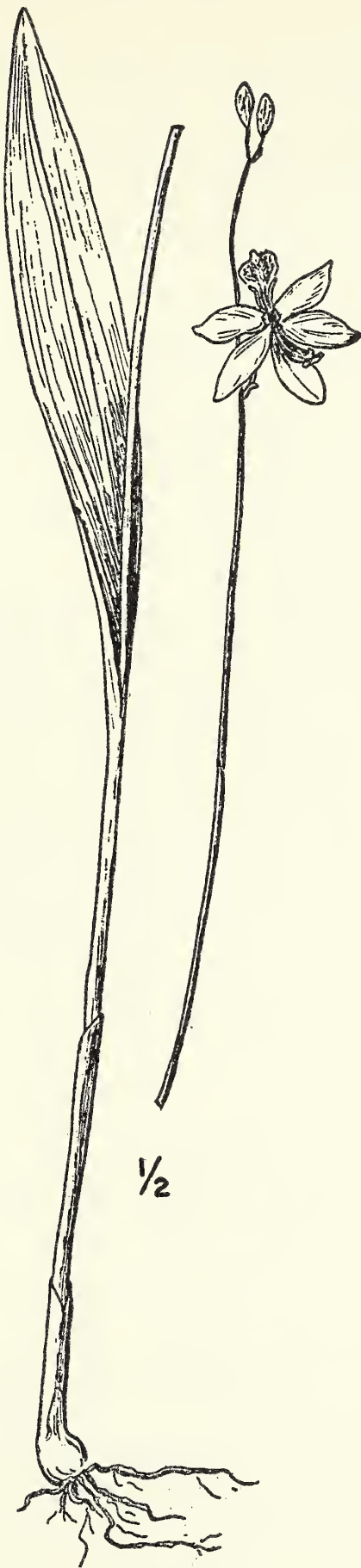


FIG. 25. *Calopogon pulchellus*

Leaves basal and extending slightly up stem, linear or linear-lanceolate; spike one-sided or loosely spiraling, downy-pubescent; flowering in late May to September4. *S. vernalis*.

Flowers in several ranks.

Lip yellow; leaves oblanceolate, fleshy, basal; flowering from May to July5. *S. lucida*.

Lip white or whitish; leaves linear-lanceolate to narrowly oblong, basal or extending up the stem.

Lip white, oblong, not contracted behind the apex, basal callosities prominent; lateral sepals free; flowering from mid-August to October6. *S. cernua*.

Lip creamy-white, fiddle-shaped or constricted behind the apex, basal callosities not prominent; lateral sepals united at base, converging with upper sepal and petals to form a hood over the column; flowering from mid-July to early September ...7. *S. Romanzoffiana*.

1. *S. Grayi* Ames. Little ladies'-tresses.

The specific name is in honor of Asa Gray, and in its usage we are following Correll. This little orchid has never been collected in western Pennsylvania; but it is easily overlooked, and so we think it will eventually turn up in the southwestern part of our area. Superficially, it is like the slender ladies'-tresses, differing from it in the single tuberous root and the all-white lip lacking the green central stripe. It occurs in several counties in West Virginia; and we have collected it in Muskingum County, Ohio, with the slender ladies'-tresses, under conditions similar to those in much of southwestern Pennsylvania. For identification of this species, the entire root should be collected and the color of the fresh flowers noted.

2. *S. lacera* Rafinesque. Northern slender ladies'-tresses.

The specific name means "torn" or "cleft." This plant, not recognized as a good species by many botanists, was segregated by Fernald as a northern variant of slender ladies'-tresses on the basis of having leaves present at flowering time (mid-July), and flowers typically one-sided, not spirally twisted. In our region, the distinction based on type of inflorescence often breaks down, but that based on leaves present at flowering time seems to hold. From our field experience, based on plants collected at Tamarack, Clinton County, and in Maine, it appears that this plant is distinct from the southern slender ladies'-tresses.

We have such plants from Centre, Clinton, McKean, and Potter counties, and some from the mountains of Somerset County.

3. *S. gracilis* (Bigelow) Beck. Southern slender ladies'-tresses. Fig. 26.

FIG. 26. *Spiranthes gracilis*

LIP PETAL $\times 4$



The specific name means "slender." In our experience, this is a plant of open grassy fields, while the northern one is found mostly in woods or thickets. It appears to bloom later than does the northern plant.

We have this species from Allegheny, Armstrong, Bedford, Butler, Centre, Fayette, Fulton, Greene, Somerset, and Westmoreland counties.

4. *S. vernalis* Engelmann & Gray. Spring ladies'-tresses. Fig. 27.

FIG. 27. *Spiranthes vernalis*

LIP PETAL $\times 4$



The specific name means "spring," the time of blooming in the southern part of its range. This plant resembles the slender ladies'-tresses, but it may be distinguished by its linear, grass-like leaves. This is characteristically a southern species, with outlying stations extending northward into Quebec. Collectors in our region should examine "apparent" specimens of slender ladies'-tresses in the hope of finding any one of three relatives that are rare—the little, the northern slender, and the spring ladies'-tresses. The Herbarium has specimens from the following localities:

Beaver County: 4 mi. SW. of Bocktown, Oct. 9, 1921, O.E.J. Fulton County: Harrisonville, Aug. 26, 1950, L.K.H. and W.E.B. McKean County: 2 mi. S. of Cyclone, Sept. 5, 1937, O.E.J.

5. *S. lucida* (H. H. Eaton) Ames. Wide-leaved ladies'-tresses. Fig. 28.

FIG. 28. *Spiranthes lucida*

LIP PETAL $\times 4$



The specific name means "shining," from the glossy leaves. This interesting little plant is widely distributed in our area in favored locations, but we would not call it common. It is abundant on the rocky flood-plain at Ohio-pyle, Fayette County, and at the edge of sandy depressions near the new beaches at Presque Isle in Erie County. It seems to be partial to sandy, coarse-grained soil. We saw it first in western Pennsylvania in springy turf near Plaingrove Bog in Lawrence County, June 8, 1946. Dr. Berkheimer reports it from Bedford County.

6. *S. cernua* (Linnaeus) Richard. Nodding ladies'-tresses. Fig. 29.

The specific name means "nodding," from the position assumed by the flowers. This is doubtless our most common orchid, and one of the latest to flower, blooming until killed by frost. It is usually found in sunlight in damp locations—wet banks, fields, ditches. The species is variable, plants differing in number of rows of flowers in the raceme, in fragrance, and in length of floral bracts.

We have variety *ochroleuca* forma *incurvum* Jennings (an upland variety with yellowish-tinged flowers, longer floral bracts, and incurved callosities) from Allegheny, Armstrong, Beaver, Erie, Lawrence, Warren, and Westmoreland counties. We have seen this form on Presque Isle, Erie County, blooming distinctly earlier than the typical species, and strongly simulating the hooded ladies'-tresses, which we have been seeking in that general location for several years. The species is widely distributed over the counties of western Pennsylvania, but has not yet been collected in Washington County.

7. *S. Romanzoffiana* Chamisso. Hooded ladies'-tresses.

This orchid was named for Count Romanzoff, a Russian statesman. It was in Miller's "Flora of Erie County," and for Pennsylvania in Gray's Manual; it is recorded from Crawford County in "Wild Flowers of Western Pennsylvania and the Upper Ohio Basin" by Jennings and Avinoff, and it has been collected in Ashtabula and Erie counties, Ohio. We have heard other reports of its occurrence in northwestern Pennsylvania, but have searched for it unsuccessfully for several summers. It resembles the nodding ladies'-tresses, but blooms earlier, has longer floral bracts, and the flowers are strongly constricted near the middle. Of course, its range is mostly far to the north of that of the nodding ladies'-tresses. We saw this plant in New Brunswick (August 15, 1950) in an arbor-vitae bog, where its companions were the small round-leaved orchid and the dwarf rattlesnake-plantain. We are not acquainted with any similar bog in western Pennsylvania.

Goodyera R. Brown. Rattlesnake-plantain

The genus is named for John Goodyer, early English botanist. The common name refers to the white markings on the plantain-like leaves, which suggested to someone the markings of a snake. These are essentially woods plants. Of the four listed in Gray's Manual, one is common here, two are quite rare, and the fourth ranges well to the north of our region.

KEY TO THE SPECIES OF GOODYERA

Raceme loosely flowered or one-sided; lip elongate.

Flowers in a one-sided raceme, lip recurved at tip; leaves 5-veined, 1-3 cm. long1. *G. repens* var. *ophioides*.

Flowers in a loose spiral, lip less recurved; leaves with 5-9 veins, 2-7 cm. long2. *G. tessellata*.

Raceme cylindrical, densely flowered, lip short-tipped; leaves reticulate with white veins3. *G. pubescens*.

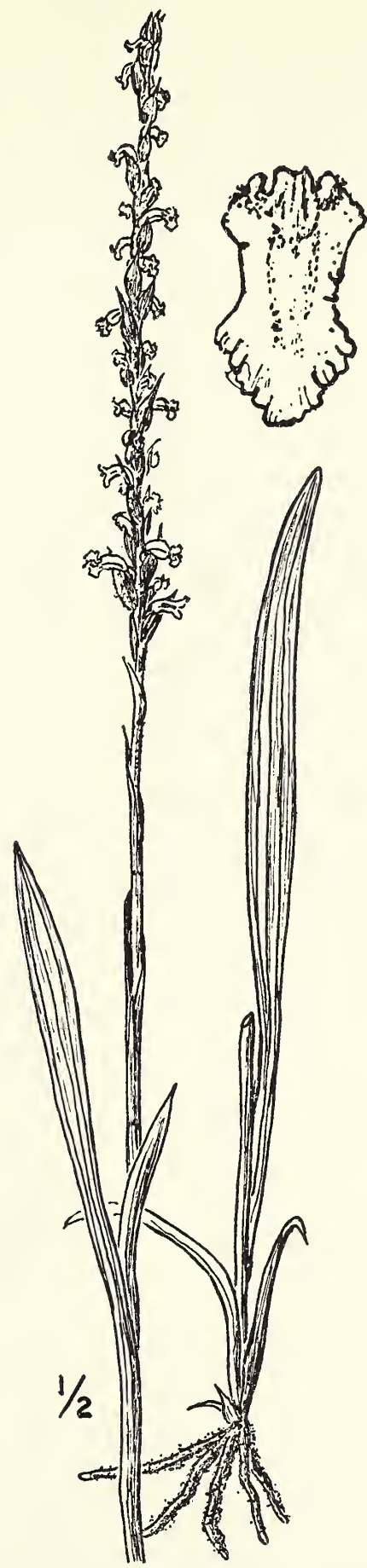


FIG. 29. *Spiranthes cernua*. LIP PETAL 1s X 3

1. *G. repens* var. *ophioides* Fernald. Lesser rattlesnake-plantain. Fig. 30.

FIG. 30. *Goodyera repens* var. *ophioides*
FLOWER $\times 5$



The specific name means "creeping," and the varietal name means "snake like." We have never seen this orchid growing in western Pennsylvania, although there are four specimens of it in the Herbarium. It blooms in July and August and is said to prefer evergreen woods. As we saw it in New Brunswick, August 15, 1950, it was growing with small round-leaved orchid and hooded ladies'-tresses in an arbor-vitae bog. One would probably have the best chance of finding it in the mountains along the eastern part of our area. It is in the Herbarium from:

Bedford County: (no locality), August 18, 1875, B. H. Patterson. Cambria County: Wildwood Springs, July 16, 1904, B. H. Patterson. Somerset County: Johnsburg, August 3, 1863, Rev. G. Eifrig.

2. *G. tessellata* Loddiges. Loddiges' rattlesnake-plantain. Fig. 31.

FIG. 31. *Goodyera tessellata*
FLOWER $\times 5$



The specific name means "checkered," from the leaf pattern. This plant resembles the lesser rattlesnake-plantain, but it is somewhat larger, and the

inflorescence is several-ranked rather than one-sided. Furthermore, it is said to prefer somewhat drier conditions. We have never collected this orchid, but will continue to look for it in our northern and western counties, since it has been collected in Warren County, in Allegany County, New York, and in Ashtabula County, Ohio. Dr. Wherry reports having collected it in Huntingdon County, and there is a specimen in the Herbarium from an evergreen woods at North Warren, Warren County, collected by H. N. Moldenke, August 7, 1944.

3. *G. pubescens* (Willdenow) R. Brown. Downy rattlesnake-plantain. Fig. 32.

The specific name means "downy," from the glandular pubescence of the raceme. This is one of our more common orchids, occurring in open woods over most of our area. It frequently grows with the large round-leaved orchid and the lily-leaved twayblade. The reticulated leaves make an attractive pattern, even when the plant is not in bloom. It flowers in July and August. We find it frequently in open deciduous woods in the Raccoon Creek drainage area in Beaver County.

According to collections in the Herbarium, it is scattered over the following counties: Allegheny, Armstrong, Beaver, Bedford, Butler, Cambria, Clinton, Crawford, Erie, Fayette, Greene, Huntingdon, Lawrence, McKean, Mercer, Somerset, and Westmoreland.

Malaxis Swartz. Adder's-mouth

The generic name means "softening," from the delicate character of the plant. This is a large genus, but not very numerous in eastern North America. Gray's Manual lists five species, of which we have three. They are small, inconspicuous, rather rare plants, of somewhat neutral coloring. Ours all grow from a corm, with a single leaf near the base of the stem.

KEY TO SPECIES OF MALAXIS

Raceme loose, elongated; lip drooping, entire, abruptly long-pointed; leaf sheathing the stem near the base ..1. *M. monophyllos* var. *brachypoda*.
 Raceme short, cylindrical; lip finally ascending, 2-lobed at summit; leaf sheathing the stem near the middle.

Raceme broadly cylindrical, lip oblong-ovate, shallowly cordate at base
2. *M. unifolia*.

Raceme narrowly cylindrical, lip broadly cordate-deltoid
3. *M. Bayardi*.

1. *M. monophyllos* var. *brachypoda* (Gray) Morris & Eames. White adder's-mouth. Fig. 33.

The specific name means "having a single leaf," and the varietal name means "short-pedicelled." Gray's Manual lists the white adder's-mouth as occurring in Pennsylvania, Correll records it from Bradford and Blair counties, and Wherry has reported a Blair County specimen (probably from the same locality as Correll's plant). The Herbarium had but one record for it (Wattsburg, Erie County) until we found a few plants in our bog near Union City, Erie County, June 29, 1949. These are the only stations we know in western Pennsylvania. It grows in the latter situation, not in the



FIG. 32. *Goodyera pubescens*. FLOWER IS $\times 5$

FIG. 33. *Malaxis monophyllos* var. *brachypoda*
FLOWER $\times 8$



open calcareous bog, but around the mucky edges, under trees and shrubs. This is probably the most difficult to see of all our orchids, although the heart-leaved twayblade runs it a close second. Some botanists treat this plant as a separate species, *M. brachypoda* (Gray) Fernald. We are following Morris and Eames, and Correll, in treating it as a variety of the Eurasian, Alaskan, and Aleutian *M. monophyllos* (Linnaeus) Swartz.

2. *M. unifolia* Michaux. Green adder's-mouth. Fig. 34.
The specific name means "one-leaved." The green adder's-mouth seems to be widely distributed in our region, but possibly because of its small size and modest coloring, it is not often collected. We have found it most common in Fayette County, around the Connellsville Reservoir, and near the Markleysburg Bog on the plateau east of Uniontown along U. S. Route 40. We first saw it at the latter station on August 2, 1947, where it was growing in sandy, fairly dry soil in very open woods. It is an inconspicuous plant, so one must look closely to see it.

We have records of it from Bedford, Cameron, Centre, Clearfield, Elk, Erie, Fayette, Mercer, Potter, and Somerset counties.

3. *M. Bayardi* Fernald. Bayard Long's adder's-mouth. Fig. 35.
The specific name is in honor of Bayard Long, companion of Fernald on many collecting trips. Fernald has separated this slender, perhaps depauperate, variant of the green adder's-mouth from the typical species, but is not followed by all botanists. Without attempting to pass on the validity of the species, we collected such plants (so identified by Wherry, who was with us when we found them) on shale barrens near Hewitt, Bedford County, on August 6, 1949. We later collected it in a similar habitat near Harrisonville, Fulton County, on August 26, 1950.

Liparis Richard. Twayblade

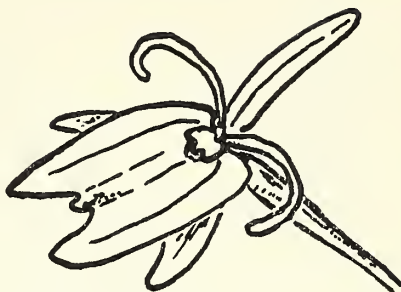
The generic name means "fat," or "shining," referring to the thick glossy leaves. False twayblade would perhaps be a better common name for this genus, which differs from *Listera* in its larger flowers and basal, rather than cauline, leaves. This is a large genus of temperate and tropical regions, with only two in the range covered by Gray's Manual. We have both.

KEY TO SPECIES OF LIPARIS

- Raceme many flowered; leaves elliptic-ovate; lip broadly cuneate-obovate, madder-purple1. *L. lilifolia*.
Raceme few flowered; leaves elliptic-lanceolate; lip oblong to obovate-spatulate, yellowish-green2. *L. Loeselii*.



FIG. 34. *Malaxis unifolia*. FLOWER IS $\times 8$

FIG. 35. *Malaxis Bayardi*FLOWER $\times 10$ 1. *L. lilifolia* (Linnaeus) Richard. Lily-leaved twayblade. Fig. 36.

The specific name means "lily-leaved." This plant is not a true twayblade, and so Wherry prefers the common name mauve sleekwort; but we are using the name most commonly used in our region. It is one of the more common orchids in the southwestern part of our area; it has also been collected in Mercer and Erie counties. It grows under the same conditions as, and often in company with, the downy rattlesnake-plantain and round-leaved orchid. We often find it in wild crab-apple thickets. It is a pretty plant, in a quiet way, with its mauve-purple flowers of odd shape, and it is one of the less difficult orchids to cultivate.

We find it scattered over the southwestern part of our region, in the following counties: Allegheny, Beaver, Bedford, Butler, Fayette, Greene, Washington, and Westmoreland. There is one record from Mercer County (Sharpsville, collected by F. T. Aschman, June 28, 1887) and one from Erie County (Presque Isle, collected by O. E. Jennings, September 22, 1906).

2. *L. Loeselii* (Linnaeus) Richard. Loesel's twayblade. Fig. 37.

The species is named for Johann Loesel, European botanist. Wherry prefers the European common name of fen orchid. Its range is mostly north of that of the lily-leaved twayblade, and it is much more rare in our region. There are three specimens from Erie County, one from Cameron, and one from Elk in the Herbarium. We have found it common only on the edges of sandy ponds near recently formed beaches at Presque Isle, Erie County, and we have seen a very few plants in our favorite bog near Union City. Dr. David Berkheimer has collected it in a mountain bog near Bean's Cove, Bedford County. The Herbarium has specimens from the following localities:

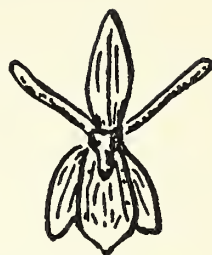
Cameron County: Miller, July 19, 1904, O.E.J. Elk County: Dents Run, July 19, 1904, O.E.J. Erie County: Presque Isle, various collectors and dates, from 1879 to 1948; 1.5 mi. E. of Wattsburg, July 31, 1928, O.E.J.; 4 mi. NE. of Union City, June 29, 1949, W. E. B. Mercer County: Sharpsville, June 28, 1887, F. T. Aschman.

Tipularia Nuttall. Crane-fly orchid

This genus has two species, one in North America and one in Asia. Both the generic and the common name refer to the fancied resemblance of the flowers to the insect genus *Tipula* or crane-fly. This plant belongs to the winter-leaf group, sending up in autumn a single leaf, which winters over and dies in late spring. Then, in midsummer, a flower spike appears and



FIG. 36. *Liparis lilifolia*. FLOWER IS $\times 2$

FIG. 37. *Liparis Loeselii*FLOWER $\times 2$ 

blooms without leaves. The crane-fly usually has three or four connected corms, gradually increasing in size, the current one the largest.

T. discolor (Pursh) Nuttall. Crane-fly orchid.

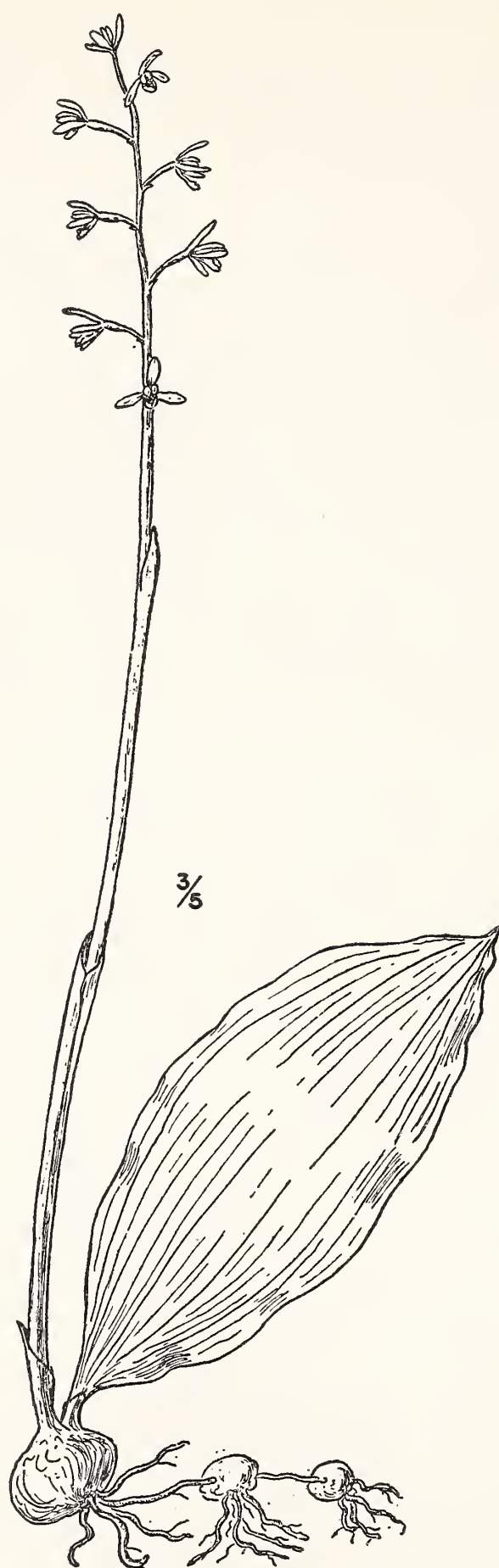
The specific name means "mottled," variously said to refer to the flowers and to the leaves. Although Wherry reports (Correll, "Native Orchids of North America", page 279) that the crane-fly orchid "ranges locally across Pennsylvania," we have no record of its having been collected in western Pennsylvania. Strausbaugh and Core report it from five West Virginia counties, and Dr. Jennings has seen it on bluffs above Ashtabula Creek, Ashtabula County, Ohio. When we collected it near Petersburg, Virginia, August 18, 1952, it was a rather conspicuous plant, and would surely have been found in western Pennsylvania unless very rare. Until we find it here, we will have to list it simply as a rather remote possibility, and we would welcome any information as to its whereabouts.

Aplectrum Nuttall. Puttyroot

The generic name means "without a spur," referring to the spurless condition of the flowers. Another member of the winter-leaf group, this genus has only one species. The corms are usually in pairs, leading to the common name Adam and Eve. The other common name, puttyroot, is derived from the mucilaginous properties of the corms, which were said to have been used by children of former times—when the plant was not so rare—as a sort of substitute for chewing gum. It may be that the relative scarcity of puttyroot is due, not only to cutting of the forests, but also to more widespread pasturing and to more general abundance of rodents, which find and eat the corms.

A. hyemale (Muhlenberg) Torrey. Puttyroot. Fig. 38.

The specific name means "of winter," in reference to the leaf which persists over winter. Years ago, before the forests were cut over, the puttyroot was probably not too uncommon in the southern part of our area. We have records from Allegheny, Armstrong, Beaver, and Butler counties; but these records are all over fifty years old. Personally, we have found the plant a will-o'-the-wisp, and could find no trace of it in western Pennsylvania until the spring of 1952, when, on April 19, we were shown the winter leaves of about half a dozen plants, in the rich humus of a deciduous woods along Ten Mile Creek, near Waynesburg, Greene County. Although these plants failed to bloom that year, we were told that puttyroot had not been excessively rare in Greene County in former years. Dr. David Berkheimer, in May of the same year, found leaves of about fifteen plants near Hyndman,

FIG. 38. *Aplectrum hyemale*

Bedford County. Like the Greene County plants, these did not bloom in 1952. However, one of the Greene County plants bloomed in May, 1953. The Herbarium includes specimens from the following localities:

Allegheny County: Moon Township near Stoops Ferry, 1887, J.A.S. Armstrong County: no locality, May and September, 1868, S. W. Knipe. Beaver County: ravine, Little Beaver River, 1900, I. F. Mansfield. Butler County: south of Butler, 1900, W. H. Reed. Greene County: 3 mi. NE. of Waynesburg, June 6, 1953, W.E.B.

Corallorhiza Chatelain. Coral-root

This is a small genus of saprophytic herbs, principally of North America, with one in Europe. Both the generic and the common name refer to the peculiar roots, which are really swollen underground rhizomes, branched and toothed, resembling coral. We have three of the five species listed in Gray's Manual, with a fourth near our southern border.

KEY TO SPECIES OF CORALLORHIZA

- Lip 3-lobed.
- Lateral lobes of lip inconspicuous; spur small; lip usually unspotted; plant greenish-yellow; flowering in spring, chiefly ...1. *C. trifida* var. *verna*.
- Lateral lobes of lip prominent; spur conspicuous; lip usually purple or red spotted; plant madder-purple to yellowish brown; flowering in summer2. *C. maculata*.
- Lip not lobed; entire, notched or denticulate.
- Lip 5-6 mm. long, notched at apex, white with purple spots; flowering in spring3. *C. Wisteriana*.
- Lip 4 mm. long, denticulate on margin, white with purple dots and purple rim; flowering in autumn4. *C. odontorhiza*.
1. *C. trifida* var. *verna* (Nuttall) Fernald. Early coral-root. Fig. 39.

FIG. 39. *Corallorhiza trifida* var. *verna*
FLOWER X 3



The specific name means "three-lobed," referring to the lip; and the varietal name means "of spring," the flowering time of the plant. This is a plant of northern distribution, barely reaching the north border of our area. Correll lists it only from Monroe County in Pennsylvania, but we have seen it at Pymatuning Swamp in Crawford County (June 14, 1947) and at our bog near Union City, Erie County. In both locations it grew on hummocks in rich leaf mold under hemlocks, in very wet woods. Our records for Pymatuning run back to 1904. We also have a specimen from Shanksville, Somerset County, collected by B. H. Patterson, in 1875.



FIG. 40. *Corallorhiza maculata*

2. *C. maculata* Rafinesque. Spotted coral-root. Fig. 40.

The specific name describes the spotted lip. While never very common, the spotted coral-root is widely distributed over western Pennsylvania. It commonly grows on wooded hillsides, showing considerable liking for the shade of hemlocks. The species is quite variable in size and coloration, and blooms from June through August.

Specimens from the following counties are in the Herbarium. Allegheny, Armstrong, Beaver, Bedford, Blair, Butler, Cameron, Clinton, Crawford, Erie, Fayette, Forest, Indiana, Jefferson, Lawrence, McKean, Somerset, Venango, Warren, and Westmoreland.

3. *C. Wisteriana* Conrad. Wister's coral-root. Fig. 41.

FIG. 41. *Corallorhiza Wisteriana*
FLOWER



The species is named for Charles J. Wister, American amateur botanist, who discovered the plant. This early-blooming coral-root was originally described from Pennsylvania, but apparently has never been found in the western part. There are records from several West Virginia counties, from Garrett County, Maryland, and from Lawrence County, Ohio. The plant has general similarity to the early coral-root, but the lip is unlobed, and the distribution is southern, not northern. It would not be surprising to find it in the southern part of our territory.

4. *C. odontorhiza* (Willdenow) Nuttall. Late coral-root. Fig. 42.

FIG. 42. *Corallorhiza odontorhiza*
FLOWER $\times 5$



The specific name means "tooth-rooted." This orchid is rather widespread, but certainly not very common. During several years of rather intensive botanizing, we can recall finding it on just two occasions—at Wymp's Gap in southern Fayette County, September 13, 1947, and in woods a few miles west of Mercer, Mercer County, in 1950. Dr. Berkheimer reports it from Bedford County. The late coral-root is similar to Wister's coral-root, but it blooms in autumn rather than in the spring. We have specimens from the following localities:

Allegheny County: Moon Township, September 13, 1890. Fayette County: 3 mi. NW. of Deer Lake, September 14, 1947, L.K.H. Fulton County: near Harrisonville, August 26, 1950, L.K.H. and W.E.B. Indiana County: 1 mi. NW. of McIntyre, October 9, 1948, Ellen Mason. Mercer County: 2 mi. NW. of Mercer, September 16, 1950, L.K.H. and W.E.B. Westmoreland County: Hillside, September 10, 1947, K. McDowell.

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ART. 21. ADDITIONAL SCOLECODONTS FROM THE POTTER
FARM FORMATION OF THE DEVONIAN OF MICHIGAN

By E. R. ELLER

Curator of Geology and Invertebrate Paleontology

INTRODUCTION

A number of years ago a small fauna of scolecodonts, fossil polychaete jaws, collected by Dr. G. Arthur Copper of the United States National Museum, were studied and the results published (Eller, 1938). From fragments and the type of jaws found it was evident that only a small portion of the fauna was originally described. Subsequent collecting has proved that the formation is extremely rich in scolecodonts. A hand specimen of the limestone, when dissolved in a weak acid solution, will produce scores of jaws, and many in a very fine state of preservation. Even if one jaw in 25 was considered as representing an individual the annelids would far outnumber any other type of invertebrates preserved in the rock. Their presence in such numbers must have been a considerable factor in the competition for food and a living space. The sea bottom was continually being disturbed and reworked by their burrows, a situation that could not be very desirable for the physical comfort of the diverse fauna and flora that wanted to occupy the same area.

Most of the specimens found were single jaws. There were perhaps a hundred specimens, however, consisting of two jaws in articulation. Workers or students only slightly familiar with this field often view with alarm the fact that a single jaw from the complex jaw apparatus is figured generically and specifically. This is especially true of those who chance on an articulated specimen. All workers that have given any serious thought to the subject state in their publications that they are obliged to describe the jaws separately and realize that they do not belong to different species. Again it is well to quote Hinde (1880) where he restated that in the classification he was "thoroughly conscious of its tentative character, as serving for paleontological reference rather than as presenting exact zoological arrangement."

The Potter Farm formation is probably Tully in age. It has not been correlated very extensively but it contains faunal elements related to those of the Cedar Valley formation of Iowa and the Thunder Bay formation. The specimens were all collected from the ledges by the side of the road about a quarter of a mile south of Four Mile Dam, Alpena County, Michigan.

DESCRIPTION OF SPECIES

Genus ARABELLITES Hinde, 1879

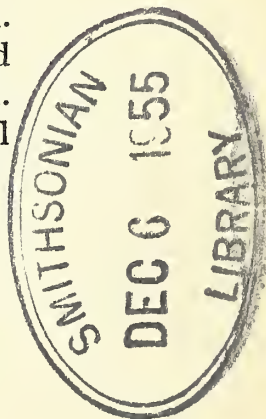
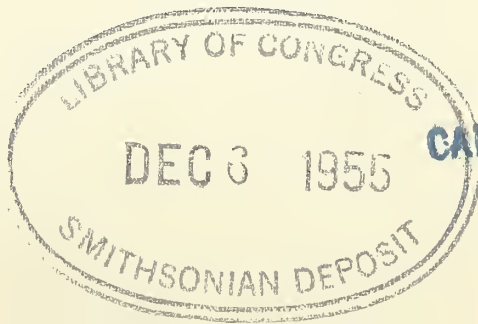
Arabellites arrectus, sp. nov.

Maxilla I. Plate 22, Fig. 1-2

The jaw is elongate and the figured specimen measures about 1.53 mm. in length. A series of seven conical, backward directed denticles is located on a narrow, elevated ridge which is nearly parallel to the inner margin. The area adjacent to the denticles is concave. The first denticle is small

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and it is followed by denticles that increase in size to about the middle where they again decrease to the posterior end. About one-half of the jaw consists of a heavy erect fang. The outer margin is notched and incurved slightly at the end of the fang to form a small shank. The inner margin is curved and its margin rounded. The posterior extremity is obliquely truncate. A large, wide fossa occupies most of the upper surface of the jaw. It is deep along the inner margin but becomes shallow at the outer margin where the area is convex.

Hinde (1882) described a species, *Arabellites contractus*, which resembles *Arabellites arrectus* except for the length and curvature of the fang and the character of the denticles. *Arabellites hamiltonensis* Stauffer (1939) is similar to *Arabellites arrectus* in a general way. They differ in the outline of the outer margin and the shape and arrangement of the denticles.

Genus NEREIDAVUS Grinnel, 1877

Nereidavus angulatus (Eller)

Maxilla I. Plate 22, Fig. 3-4

Eunicites angulatus Eller 1938. Annals of the Carnegie Museum, v. 27, p. 278, plate 28, Fig. 15.

The posterior portion, especially the fossa of *Eunicites angulatus* Eller (1938), is similar to that found in many left jaws of *Nereidavus*. The lack of denticles was the reason for the form being originally placed in the genus *Eunicites*. Since the original description a number of species of *Nereidavus* have been described from various horizons, Eller (1940, 1941, 1942, 1945), that are similar to *Eunicites angulatus*. Some of these jaws have a series of small sharp-pointed denticles, some only a few minute, blunt teeth scattered along the margin, while other specimens have none at all. Denticles have not been found on the inner margin of *Eunicites angulatus*. The species is being placed in the genus *Nereidavus* because of the posterior structures and since some forms of the genus lack denticles.

Nereidavus? admixtus sp. nov.

Maxilla I. Plate 27, Fig. 2

The jaw is small, elongate, and the figured specimen measures 0.44 mm. in length. A series of 10 conical, sharp-pointed denticles extends nearly to the posterior end. The first denticle is slightly larger than the other teeth. The second denticle is small and the remaining ones are nearly uniform in size. The first two or three denticles point forward while the posterior five or six are directed backwards. The outer margin is nearly straight and then curves abruptly to form a truncate shank that is thickened along the posterior margin. The lateral margins of the shank are incurved and the surface is irregular.

The lack of a fossa makes this form different and not simple to place generically. The truncate shank with the thickened posterior margin suggests a surface of articulation with a carrier. This is typical of a number of modern genera including *Arabella*, *Leodice* and *Drilonereis*. There is a similarity between *Arabellites clarkii* Eller, 1934 and *Nereidavus? admixtus*.

Genus *ILDRAITES* Eller, 1936*Ildraites appressus* sp. nov.

Maxilla II. Plate 27, Fig. 1

The jaw is wide and subtriangular in outline. The figured specimen measures 0.72 mm. in length and 0.35 mm. in width. On the curved inner margin a series of 16 conical, sharp to blunt denticles extends nearly to the posterior end. The fang is large, narrow, sharp-pointed and directed slightly forward. The next seven denticles are small and needle-like, and decrease in size posteriorly. These are followed by eight larger, blunt, pressed together, backward directed denticles that increase in size to about the middle and then gradually decrease in size to the posterior end. On the curved outer margin a wide, deep, crescent-shaped bight forms a short, wide shank and a narrow posterior area. A deep fossa occupies part of the upper side of the jaw. The margins of the fossa are slightly thickened and rounded. The upper side of the jaw is highly convex while the under side is flattened.

There is a similarity between *Ildraites appressus* and *Ildraites howelli* Eller (1941) especially in the arrangement of the denticles. They differ in the width of the jaw and the curvature of the outer margin. No attempt will be made to compare *Ildraites appressus* with *Paulinites paranaenses* Lange (1947), maxilla II, right jaw (labeled left in Lange's paper) since it is probably specifically the same as *Ildraites howelli* Eller. Hinde (1882) described a species, *Arabellites anglicus* Hinde, from the Silurian of Gotland, in which the denticles occupy the full length of the inner margin similar to *Ildraites appressus*. They differ mostly in the width of the posterior part of the jaw and the character of the anterior denticles and fang. *Arabellites priscus* Stauffer (1939) resembles *Ildraites appressus* in a general way, but Stauffer's species differs in that it is narrower, has a more shallow bight, a heavier fang, and denticles set at a different angle.

Genus *LEODICITES* Eller, 1940*Leodicites angiformis*, sp. nov.

Maxilla II. Plate 22, Fig. 5-6

The jaw is elongate, subtriangular in shape. The figured specimen measures 0.56 mm. in length. Along the straight inner margin a series of ten, conical, sharp-pointed, backward directed denticles extends the full length of the jaw. The fang is of medium size and is directed backwards nearly perpendicularly to the anterior margin. The second denticle is large and is followed by a very small one. The remaining denticles are large in comparison to the size of the jaw. They decrease only slightly in size to the posterior end. The anterior margin is slightly incurved and forms a small, sharp-pointed shank with the straight outer margin. A deep, narrow fossa extends the full length of the jaw and occupies most of the upper side. The margins of the fossa are thin.

There is a resemblance in the general shape between *Leodicites antifixus* Eller (1945), *Leodicites barbatus* Eller (1942), *Leodicites artus* Eller (1945) and *Leodicites angiformis*.

***Leodicites altilis* sp. nov.**

Maxilla II. Plate 22, Fig. 7-8

The jaw is large, wide, and subtriangular in shape. The figured specimen measures 1.48 mm. in length and 0.86 mm. in width. Along the curved inner margin a series of nine blunt, triangularly shaped denticles extends nearly to the narrow posterior extremity. The denticles are not uniform in size. A small anterior denticle is followed by a larger one. The third denticle is usually the largest and it is followed by smaller denticles of various sizes. All denticles are directed backwards and overlap each other. The anterior margin is rounded from the fang and then becomes straight to the pointed shank. A deep crescent-shaped bight on the outer margin emphasizes the length of the shank. Along the lower half of the bight and mostly on the under surface is a rounded ridge. A triangularly shaped fossa is present on the upper surface of the jaw. A thickened margin with well rounded edges surrounds the fossa. The under surface at the posterior half is slightly concave causing the fossa to be shallow.

Leodicites reimanni Eller (1941) is similar in a general way to *Leodicites altilis*. The arrangement of the denticles and the position of the shanks of the two forms are quite different.

***Leodicites abbreviatus* sp. nov.**

Maxilla II. Plate 22, Fig. 9-11

In outline the jaw is small, subtriangular and rather wide in proportion to its length. The figured specimen measures 0.32 mm. in length and 0.27 mm. in width. A series of eight conical, sharp-pointed denticles extends along the full length of the slightly curved inner margin. The fang is sharp, hooked, and not in alinement with the other denticles. Following the fang the denticles decrease regularly in size to the posterior end and are nearly perpendicular to the under side of the jaw. The outer margin curves from the fang and is notched by a crescent-shaped bight which forms a wide, blunt shank. A wide, shallow fossa occupies most of the upper surface of the jaw. The margins of the fossa are rounded. The surface of the jaw is crossed by a deep depression.

Leodicites abbreviatus is similar to *Leodicites absolutus* Eller (1945). They differ from each other in the number and character of the denticles, the shape of the shank, and the surface features.

***Leodicites amplicameratus* sp. nov.**

Maxilla II. Plate 27, Fig. 3-4

In outline the jaw is subtriangular and elongate. An average specimen measures 1.30 mm. in length. Along the inner margin a series of sharp, triangular-shaped, backward directed denticles extends the full length of the jaw. The first denticle is small and is followed by teeth that become progressively larger to about the middle and then gradually become smaller to the posterior extremity. A small bight is present on the outer margin. It forms with the broadly rounded anterior margin a small, angular shank. The upper side is irregularly convex except for a concave area that extends

obliquely from the anterior end to the shank. A large-chambered, shallow fossa occupies most of the upper side of the jaw.

All specimens of this species were found broken. *Leodicites ampli-cameratus* does not very closely resemble any other species.

***Leodicites ambiguus* sp. nov.**

Maxilla II. Plate 27, Fig. 5-6

The jaw is narrow and elongate. A figured specimen measures 0.78 mm. in length. On the inner margin a series of six conical, sharp-pointed, backward directed denticles extends the full length of the jaw. The first denticle is large and is followed by a small tooth. The remaining denticles become progressively larger posteriorly to the final tooth which is nearly as large as the first denticle. The anterior margin is extended obliquely with the outer margin to form a long, straight-sided, truncate shank. A deep fossa occupies the complete upper side of the jaw including the shank.

The position and shape of the shank and the character of the denticles do not correspond to any other species of the genus. The shank of *Leodicites anticus* Eller (1945) curves forward slightly as in that of *Leodicites ambiguus*.

***Leodicites angusticameratus* sp. nov.**

Maxilla II. Plate 27, Fig. 7.

The jaw is small, subtriangular in outline and the figured specimen measures 0.45 mm. in length. Along the inner margin a series of six or seven conical, sharp-pointed, forward directed denticles extends the full length of the jaw. The first denticle is large and the remaining teeth gradually become smaller posteriorly. The anterior margin curves forward and with the outer margin forms a small, acute shank. The surfaces of the jaw are flattened or slightly convex. A narrow-chambered fossa extends the full length of the jaw including the shank.

This form is similar to *Leodicites streetsvillensis* Eller (1942) and *Leodicites anticus* Eller (1945) except for the size of the shank, arrangement and character of the denticles, and the length of the jaw. There is a slight resemblance in general shape between *Leodicites angusticameratus* and *Leodicites caleyi* Eller (1944).

Genus STAUROCEPHALITES Hinde, 1879

***Staurocephalites aequilateralis* sp. nov.**

Maxilla II. Plate 22, Fig. 12-29

The jaw is narrow, elongate, and nearly as wide at the posterior extremity as at the anterior end. Measurements of the figured specimens range between 0.59 mm. and 0.76 mm. in length. A straight inner margin bears a series of 12 to 14 conical, backward directed denticles which extend nearly to the posterior end. The first eight denticles are large and decrease only slightly in size posteriorly. The remaining four to six denticles are small and also decrease very little in size. The first denticle appears to be a continuation of the margin. The anterior end of the jaw is truncate while the posterior end is rounded. A fossa occupies the complete upper side of the jaw. The upper margin of the fossa is rounded while the under margin is thin and

often broken. On the upper surface of some specimens, and parallel to the described denticles, is a small jaw or group of minute teeth extending nearly the full length of the jaw. The second row of denticles may be a part of a separate jaw but in some specimens it is so tightly articulated that a suture line is not discernible. There does not seem to be a separate fossa. It has not been determined whether this secondary jaw is a maxilla III or a connective part. In modern polychaeta the maxillae are not closely articulated especially when the mouth is extended.

There is a slight similarity between *Staurocephalites aequilateralis* and *Staurocephalites triplus* Eller (1945). They differ in the number and type of denticles and the width of the jaw as compared with the length.

***Staurocephalites articulatus* sp. nov.**

Maxilla II or III. Plate 23, Fig. 1-3, 7

The jaw is large and a figured specimen measures 1.64 mm. in length. The anterior end is obliquely truncate while the posterior extremity is well rounded. Along the inner margin a series of 16 to 18 sharp-pointed, conical, backward directed denticles extends more than three-quarters the length of the jaw. The first denticle is large and is followed by two or three small, closely spaced teeth. The remaining denticles are large and decrease in size only slightly at the posterior end. The area of the under side of the jaw is about twice as great as the upper side. A large shallow fossa extends the full length of the upper side of the jaw. The upper margin of the fossa is thickened while the under margin is thin and often broken.

On the under side of several specimens a small, thin jaw is found in articulation. From 13 to 19 sharp-pointed, backward directed denticles of nearly uniform size extend along the curved inner margin nearly to the posterior end. The anterior end of the jaw is acute while the posterior end is well rounded. The margin of the anterior end is slightly folded. A narrow fossa occupies the upper side of the jaw. The margins of the fossa are thin and usually broken. The figured specimens measure from 0.59 mm. to 0.82 mm. in length.

Since the smaller jaw, probably a maxilla III, of the articulated specimens is a part of a natural species no special designation will be given to it. Neither of these forms resemble very closely any other species.

***Staurocephalites aequemarginalis* sp. nov.**

Maxilla II. Plate 23, Fig. 4-6

Both the anterior and posterior ends or margins of the jaw are truncate and equal in width. Along the inner margin a series of 13 backward directed denticles extends nearly to the posterior extremity. The first denticle is large and appears to be an extension of the thickened margins. The second denticle is usually small. It is followed by five or six larger teeth and then by five or six denticles that are much smaller. The upper surface of the jaw is concave or flattened. A narrow fossa occupies the full length of the jaw. The figured specimens average about 0.65 mm. in length.

The form does not very closely resemble any other described species.

***Staurocephalites alterostris* sp. nov.**

Maxilla II. Plate 23, Fig. 8-15

In size the jaw is large, measuring from 0.86 mm. to 1.53 mm. in length. The width, as compared with the length, is great, the ratio being about four to one. A series of 13 to 18 triangular shaped, sharp-pointed, backward directed denticles extends along the inner margin nearly to the posterior extremity. The first denticle is large and appears to be part of the inner margin. The remaining denticles are slightly smaller at the anterior and posterior ends than at the center of the jaw. The anterior end of the jaw is extended to a high and acutely pointed beak while the posterior end is well rounded. The sides of the jaw are flattened or slightly concave. This is reflected in a narrow fossa which occupies the complete upper surface of the jaw. The margins of the fossa are thin and usually incomplete.

The acute anterior extremity of *Staurocephalites pyramis* Eller (1944) and *Staurocephalites alterostris* is similar. The forms differ in the size and in the arrangement of the denticles.

Genus OENONITES Hinde, 1879***Oenonites aequibrachiatus* sp. nov.**

Maxilla II. Plate 23, Fig. 16

The jaw is subtriangular, wide anteriorly, and tapers to a blunt posterior end. The figured specimen measures 0.52 mm. in length. Along the inner margin a series of 11 conical, sharp-pointed, backward directed denticles extends the full length of the jaw. The first denticle is slightly larger than the rest of the series. The other denticles are nearly equal in size, decreasing only slightly to the posterior. The upper surface of the jaw is irregularly concave and contains about one-half the area of the under surface. A shallow fossa extends the full length of the upper side. The margins of the fossa are slightly thickened.

Except for the width of the jaw and the character of the denticles *Oenonites aequibrachiatus* resembles *Oenonites coggeshalli* Eller (1945) and *Oenonites imparidentatus* Eller (1945). There is a similarity between some specimens of *Oenonites grandidentatus* Eller (1934) and *Oenonites aequibrachiatus*. They differ in the type of denticles and the length as compared with the width of the jaws.

***Oenonites abscisus* sp. nov.**

Maxilla I. Plate 23, Fig. 18-19

The jaw is narrow and subtriangular in outline, and abruptly truncate at the posterior end. Along the inner margin a series of 10 large, conical denticles extends about three-fourths of its length. The first denticle or fang is large and is followed by three teeth of nearly the same size. These denticles point in various directions, from forwards to backwards. The remaining denticles are smaller and decrease slightly in size to the posterior extremity. The wide posterior end is indented by a shallow bight which forms a small shank at the outer margin. A wide, deep fossa occupies more than one-half

of the upper surface. The margins of the fossa are thickened and rounded. The figured specimen measures 0.52 mm. in length.

Oenonites abscisus does not very closely resemble other species of this genus.

***Oenonites orthodontus* ? Eller**

Maxilla I. Plate 27, Fig. 15

Oenonites orthodontus Eller, 1938 (Annals of the Carnegie Museum, v. 30, p. 280, plate 28, Fig. 11-12).

Many additional specimens of this form were found in the fauna. It was noticed that the outer margin in about half of the specimens was not straight as shown in the original figures. Whether this shank-like protuberance constitutes a specific difference will not be decided at this time.

Genus PALEOENONITES Eller, 1942

***Paleoenonites auctificus* sp. nov.**

Maxilla II. Plate 23, Fig. 17

The shape of the jaw is irregularly rectangular and the width is nearly equal to the length. Some specimens resemble a parallelogram. The inner margin is straight and bears from six to nine small, conical denticles that extend nearly to the posterior end. The fang is larger than the other denticles and is hooked. The denticles decrease in size posteriorly and are pointed in a backward direction. The anterior margin is irregularly curved but forms a wide angle with the nearly straight outer margin. The posterior end is enlarged and forms nearly right angles with the lateral margins. A wide, shallow fossa occupies most of the upper surface of the jaw. The area on the upper surface between the margin of the fossa and the denticles is very narrow. In length, jaws average about 0.33 mm.

Only a few specimens of this species were found. In shape, *Paleoenonites auctificus* does not agree with many other forms. *Paleoenonites accuratus* Eller (1942), *Paleoenonites dillae* Eller (1945) and *Paleoenonites parallelus* Eller (1944) have a similar angular shape and wide posterior margin. They differ in other characteristics such as the shape of the fossa and the size and arrangement of the denticles.

***Paleoenonites angiportus* sp. nov.**

Maxilla II. Plate 23, Fig. 20-22, 26-27

In outline, the jaw is irregularly rectangular, wide anteriorly, and the lateral margins taper slightly to the truncate posterior extremity. The anterior margin is indented by an irregularly shaped bight that is deeper in the left jaws and forms two small shanks. Along the inner margins a series of 10 to 12 blunt, conical denticles extends nearly the full length of the jaw. The first denticle or fang is large and when viewed from the upper side appears to be a continuation of the thickened anterior margin. The remaining denticles decrease slightly in size to the posterior. On the upper surface a narrow fossa extends the full length of the jaw. The passage is

constricted near the middle giving it the shape of a figure eight. The inner margin of the fossa is thickened and triangular in outline while the outer margin on the upper side is irregularly rounded. The under side of the jaw is concave and the upper side is convex. A typical specimen measures 0.43 mm. in length.

The species conforms well with the genus but it does not resemble *Paleoenonites alpenaensis* (Eller) from this horizon (or any other species) closely enough to warrant comparisons.

***Paleoenonites armigerus* sp. nov.**

Maxilla II. Plate 23, Fig. 23, 25

The jaw, in outline, is triangular, wide anteriorly, and the lateral margins taper to an acute posterior extremity. The inner margin is armed with a series of about twelve, large, conical, sharp to blunt, denticles which extend nearly the full length of the jaw. The anterior denticles are large and point forward while the posterior ones decrease uniformly in size and point backwards. The fang is large and is a continuation of the lateral margins. Specimens average about 0.7 mm. in length. The anterior margin is slightly incurved and forms a small, acute shank with the outer margin. On the upper surface a narrow, irregularly shaped fossa extends the full length of the jaw. The inner margin of the fossa is broadly triangular while the anterior margin is irregularly incurved. Both margins are slightly thickened and rounded. The under surface of the jaw is convex while the upper surface between the fossa and denticles may be concave or flattened.

Paleoenonites armigerus is similar in outline to *Paleoenonites acutus* Eller (1945), *Paleoenonites latissimus* Eller (1942), *Oenonites kopfi* (1940), *Oenonites fornicatus* Eller (1940) and *Oenonites radula* Hinde (1882). They differ mostly in the character and shape of the fossa. The denticles, especially the anterior ones, are large as compared with those of other species.

***Paleoenonites alpenaensis* (Eller)**

Maxilla II. Plate 23, Fig. 24

Oenonites alpenaensis Eller, 1938 (Annals of the Carnegie Museum, v. 27, p. 280, plate 29, Fig. 1-2).

When large numbers of specimens of both left and right jaws were examined it was noticed that the first three denticles were comparatively large and the remaining ones uniformly small. In the original description it was not noted that the anterior margin is rounded near the fang and then incurves to form a forward-pointing shank with the outer margin.

***Paleoenonites andaculus* sp. nov.**

Maxilla II. Plate 27, Fig. 8-10

The under side of the jaw is narrow and subtriangular in outline. The figured specimens measure from 0.45 mm. to 0.62 mm. in length. On the inner margin a series of eight triangular-shaped, blunt to sharp-pointed denticles extends nearly the full length of the jaw. The first denticle is

large and bold and is followed by teeth that become smaller to about the middle where they diminish rapidly in size to the posterior end. In most specimens the teeth are perpendicular to the inner margin. The outer margin on the upper side is straight or slightly curved, thickened, and rounded. The outer margin on the under side is thin and extended posteriorly to form a large shank. The upper surface of the jaw is slightly concave while the under surface is convex. A narrow fossa extends the length of the jaw.

There are many specimens of this form in the fauna. In all cases the shank is broken. It was probably large and extended in a backward direction. The species does not correspond very well to other described forms. Figure 30 of *Paleoenonites clinatus* Eller (1945) is slightly similar.

***Paleoenonites arcuatellus* sp. nov.**

Maxilla II. Plate 27, Fig. 11-12

The jaw is small, arched, subtriangular in outline, wide anteriorly, and tapers to an acute posterior extremity. The figured specimen measures 0.38 mm. in length. On the inner margin a series of nine or ten, thin, very sharp, conical, backward directed denticles occupies the full length of the jaw. The first denticle is small and is followed by two progressively larger ones. The fourth tooth is minute. The next three are medium and uniform in size. The remaining denticles are small. On the upper surface a deep fossa, wide anteriorly and narrow posteriorly extends the full length of the jaw. Its margins are partly thickened and rounded. The upper surface of the jaw is concave while the under surface is highly convex. The outer margin at the anterior end is rounded and extended to form a small shank.

It was rather difficult to place this species generically. If the extended portion on the outer margin is a shank, then the form belongs in the genus *Paleoenonites*. Except for the size of the shank *Paleoenonites arcuatellus* is similar to *Paleoenonites clinatus* Eller (1945). *Paleoenonites arcuatellus* and *Oenonites excavatus* Eller (1941) are similar in general shape and in the arrangement and character of the denticles. They differ in that the outer margin of *Oenonites excavatus* is thickened and rounded while the margin of *Paleoenonites arcuatellus* is thin and extended at the anterior end.

Genus EUNICITES Ehlers, 1868

***Eunicites apicalis* sp. nov.**

Maxilla IV or V. Plate 24, Fig. 1

In outline, the jaw is subtriangular measuring 0.94 mm. in length and 0.75 mm. in width. From the wide base the jaw tapers rapidly to a narrow, sharp-pointed, conical, forward directed denticle. A wide fossa occupies most of the posterior end. The margins of the fossa are thickened and rounded, especially anteriorly, and the upper one appears to be grooved. The posterior margin is extended and forms a small, hooked shank with a lateral margin.

Eunicites denticuleatus Eller (1942) and *Eunicites whiteae* Eller (1945) resemble *Eunicites apicalis* in proportions but differ in the shape of the fossa and curvature of the posterior margin. The forward pointing of the denticle is a departure from the usual backward direction.

Eunicites acidus sp. nov.

Maxilla IV or V. Plate 24, Fig. 2

The jaw is a single denticle with a small, narrow, irregularly shaped shank. The denticle is conical, sharp pointed and backward directed. A round or oval fossa occupies the posterior area. The margins of the fossa are thickened and rounded. The upper margin of the fossa is slightly extended at the posterior end. The figured specimen measures 0.32 mm. in length.

Except for the shape of the fossa and the position and shape of the shank there is a similarity between *Eunicites acidus* and *Eunicites aculeus* Eller (1945) and *Eunicites whiteae* Eller (1945). *Eunicites anquisitus*, Plate 24, Fig. 10-11, is similar to *Eunicites acidus* but differs in the size and shape of the shank.

Eunicites alveolaris sp. nov.

Maxilla IV or V. Plate 24, Fig. 3

The jaw is a single denticle or fang extending from a wide, incurved base. The denticle is flattened, sharp-pointed, backward directed with a concave area or small channel extending nearly the full length of the jaw. A very narrow fossa occupies the posterior region of the jaw. The figured specimen measures 0.83 mm. in length.

There is a question whether this jaw might not be a maxilla I or a forceps. Its similarity to many modern maxilla IV and V and the width of the posterior as compared with the length of the jaw are reasons why it is placed in a minor category at this time. *Eunicites petasus* Eller (1940) is similar except for the shape of the fossa and the roundness of the denticle in cross-section.

Eunicites asaphus sp. nov.

Maxilla IV or V. Plate 24, Fig. 4; Plate 27, Fig. 22

The jaw is flattened, wide posteriorly and tapers abruptly to a sharp-pointed, backward directed denticle. The posterior margin is thin and broken in all specimens. An irregularly shaped fossa is present on the upper side. The margins of the fossa are slightly thickened. The figured specimen measures 1.02 mm. in length and 0.41 mm. in width.

There is some question as to whether this form might not be a maxilla I. The shortness of the denticle, however, suggests that it is a minor maxilla. This species conforms well with this genus but it does not resemble any other species closely enough to warrant comparison. The thinness and poor preservation of the posterior margin of maxilla IV and V often occur in polychaete jaws.

Eunicites altidorsalis sp. nov.

Maxilla IV or V. Plate 24, Fig. 5

The jaw consists of a single, heavy, subtriangular denticle that tapers gradually from a wide, nearly straight base to an acute, high-backed, anterior end. The figured specimen measures 0.83 mm. in length and 0.59 mm. in

width. The outer margin may be slightly curved inward or outward or it may be straight. The inner margin is straight to the posterior end where it turns abruptly to form a shank with the posterior margin. A narrow fossa extends the full length of the upper surface of the jaw.

There is a general similarity between *Eunicites altidorsalis* and other jaws of this type. It differs from *Eunicites apicalis*, Plate 24, Fig. 1, and *Eunicites admirandus*, Plate 24, Fig. 9, in the shape of the fossa and the shank.

***Eunicites acutirustris* sp. nov.**

Maxilla IV or V. Plate 24, Fig. 6

The jaw is composed of a single denticle with a wide base and shank. The denticle is triangular in outline, conical, sharp pointed and tapers rapidly to the anterior end. A wide fossa, with thick, rounded margins, occupies about one-half of the upper side of the jaw. The upper margin is nearly straight while the inner margin curves posteriorly to form a heavy shank. The jaw is nearly as wide as long and the figured specimen measures 0.42 mm. in length and 0.4 mm. in width.

Eunicites acutirustris is similar to *Eunicites ansatus* Eller (1945) except for the shortness of the denticle and the shape and size of the shank. This form is represented by a large number of specimens in the fauna.

***Eunicites apidodus* sp. nov.**

Maxilla V. Plate 24, Fig. 7-8

The jaw is a single, sharp-pointed, nearly straight, cone-shaped denticle. A large fossa occupies part of the upper surface and extends about one-third the way along the anterior edge of the jaw. The posterior margin is truncate and nearly at right angles with the lateral margins. The figured specimens measure 0.44 mm. and 0.56 mm. in length and 0.16 mm. and 0.27 mm. in width at the posterior end.

This form is common in the fauna but does not resemble very closely any other species. It is similar to *Eunicites cavus* Eller (1945) except for the posterior end and shank.

***Eunicites admirandus* sp. nov.**

Maxilla IV or V. Plate 24, Fig. 9

The jaw is a single, subtriangularly shaped, sharp-pointed, conical backward directed denticle. The figured specimen measures 0.72 mm. in length and 0.46 mm. in width. A wide fossa occupies more than half the area of the upper surface of the jaw. The outer margin of the fossa is thickened, especially at the posterior end. The inner margin curves from the denticle and forms a small irregular shaped shank with the posterior margin.

Specimens of this type are common in the fauna. *Eunicites denticulatus* Eller (1942) and *Eunicites whiteae* Eller (1945) resemble *Eunicites admirandus* except for the shape of the fossa and the curvature of the posterior margin. *Eunicites admirandus* has a similar posterior margin but the fossa and the direction in which the denticle points are different.

***Eunicites anquisitus* sp. nov.**

Maxilla IV or V. Plate 24, Fig. 10-11

The jaw is a long, slender, sharp-pointed, forward directed denticle. A round fossa with heavy, rounded margins is present at the base of the denticle. Adjacent to the fossa is a rectangularly shaped, handle-like, shank that is at right angles with the denticle. The figured specimens measure 0.54 mm. and 0.52 mm. in length.

Eunicites aculeus Eller (1945) is similar to *Eunicites anquisitus* except for the position of the fang in relation to the denticle. Jaws of this kind are common in recent polychaeta.

***Eunicites acinaciformis* sp. nov.**

Maxilla I. Plate 24, Fig. 12-13

The forceps is long, gently curved, narrow and rounded anteriorly, wide and flattened posteriorly. The figured specimens measure 0.81 mm. in length. The posterior margin is notched by a crescent-shaped indentation. A small irregularly shaped fossa occupies the posterior area. On the upper side the margin of the fossa is wide and rounded. Most of the jaw is convex except for a triangular area on the under side adjacent to the fossa.

Many recent species have similar forceps. The shape and position of the fossa are unlike those of other forms of *Eunicites*.

***Eunicites articulatus* sp. nov.**

Maxilla I. Plate 24, Fig. 14, 18-21

The jaw or forceps is long, angular, flattened and wide posteriorly and is well hooked at the anterior end. When viewed from the side it may be seen that the inner margin curves rapidly from the hook to about the midpoint where the margin becomes straight. The posterior margin is wide and nearly truncate. The outer margin is nearly straight in the posterior half or two-thirds of the jaw and then curves rapidly to form the hook. A large, deep fossa occupies nearly half the jaw. The margins of the fossa are thickened and rounded. The two figured specimens measure 0.45 mm. and 0.78 mm. in length and 0.16 mm. and 0.39 mm. in width at the widest part.

Although this species conforms well with the genus, it does not resemble other species closely enough to warrant comparisons. Many modern polychaete forceps have a similar wide posterior end.

***Eunicites apiculatus* sp. nov.**

Maxilla IV or V. Plate 24, Fig. 15-17

The jaw consists of a short, sharp-pointed, conical, straight or slightly curved denticle extending nearly at right angles from a large, heavy, angular base. In most specimens a large fossa occupies nearly two-thirds of the upper surface of the jaw. The margins of the fossa are very thick and rounded. Between the denticle and the fossa is a flattened or slightly concave area that appears to be a point of leverage or attachment for the muscle. From the denticle the inner margin curves broadly to the posterior end. The figured specimens measure 0.75 mm. in length.

Arabellites uncinatus Hinde (1882) is similar to *Eunicites apiculatus*

except for the length of the base and the curvature of the denticle. In several modern polychaete genera, *Lumbrinereis*, *Drilonereis*, *Arabella*, and *Aglaurides*, the fourth and fifth maxilla is a single tooth not unlike *Eunicites apiculatus*.

***Eunicites acutulus* sp. nov.**

Maxilla IV or V. Plate 24, Fig. 22

The jaw is small and is composed of a single denticle extending from an irregularly shaped, forward directed base or shank. The denticle is thin, conical, straight and sharp pointed. The outer margin is straight but curves at the posterior end. The inner margin is straight to the base where it forms an acute angle with the posterior margin. A deep fossa occupies the entire posterior area. The posterior margin is slightly incurved. The described specimen measures 0.48 mm. in length.

Eunicites acutulus is very similar to *Eunicites whiteae* Eller (1945) and *Eunicites denticulatus* Eller (1942). They differ from each other in the length and width of the denticle, the shape of the fossa, and the position of the shank.

***Eunicites ambocoelius* sp. nov.**

Maxilla V. Plate 24, Fig. 23

The jaw is a single, short, cone-like denticle that tapers rapidly to a blunt anterior end. The width of the figured specimen is 0.41 mm. and the length is slightly less. The posterior part of the jaw is subrectangular in outline and the margins are nearly at right angles with each other. A narrow, shallow fossa is present along two margins of the posterior end. When viewed from the under side a high protuberance is present at the posterior area. This is reflected on the upper side by a concavity.

Except for some general features, this species is unlike other forms.

***Eunicites conus* (Eller)**

Maxilla IV or V. Plate 24, Fig. 24-25

Arabellites? conus Eller, 1938, Annals of the Carnegie Museum, v. 27, p. 277, 278, plate 29, Fig. 7.

A number of specimens of this type were found in the fauna. The fang is either pointed or blunt and is directed backwards. The posterior margin is often broken but it forms a wide shank with the inner margin. The figured specimens measure 0.84 mm. and 0.89 mm. in length. Since the fang is directed backwards the jaw must be located in the posterior part of the mouth. Thus, the form is probably a IV or V maxilla and should be under the genus *Eunicites* for the best paleontological reference.

***Eunicites axinus* sp. nov.**

Maxilla IV or V. Plate 24, Fig. 26

The jaw is a single, sharp-pointed, conical, forward directed, ax-shaped, denticle attached to a large square or rectangular base. The figured specimen measures 0.64 mm. in length and 0.43 mm. in width. A narrow fossa

extends for about half the length of the upper side of the jaw. Adjacent to the fossa is a wide base or shank which is straight sided and slightly concave on the upper side.

The wide base or shank of *Eunicites axinus* must have given considerable leverage and strength to the jaw. In this manner it is similar to *Eunicites ansatus* Eller (1945) but otherwise the jaws do not correspond very closely.

***Eunicites angulatus* Eller**
Maxilla I. Plate 25, Fig. 1-2

Eunicites angulatus Eller, 1938, Annals of the Carnegie Museum, v. 27, p. 278, plate 28, Fig. 13.

In the original description a left jaw was described. A right jaw illustrated herewith corresponds very well except that it is not as angular in cross-section and the surface is more even. On the under side of the forceps at the posterior end there is an oval-shaped concave area surrounded by a raised, well rounded margin. The figured specimen measures 2.59 mm. in length.

***Eunicites? alienus* sp. nov.**
Maxilla IV. Plate 26, Fig. 9

The jaw consists of an elongate, curved, subtriangular denticle which tapers gradually from a truncate posterior end to an acute anterior end. The figured specimen measures 0.62 mm. in length and 0.16 mm. in width at the posterior end. A series of long needle-like denticles occupies about two-thirds of the inner margin and extends nearly to the posterior end. The denticles are about equal in size and directed abruptly forward. A fossa is restricted to the posterior end and to a small area of the upper surface.

The spine-like teeth differ from the denticles found on most jaws. In a paper (Eller, 1945) on the scolecodonts found in the Trenton Series a number of forms having minute, thorn-like crenulations or serrations were described. The species were placed in the genus *Eunicites* until further study could be given them. The above described jaws are also assigned to the genus *Eunicites* until more material is available.

***Eunicites altinsculus* sp. nov.**
Maxilla IV or V. Plate 27, Fig. 13-14

The jaw is rather high, large, triangular in shape, and consists of a long shank or plate with a short, conical denticle at the anterior end which is at right angles to the lateral margins. The figured specimens measure 0.54 mm. and 0.64 mm. in length and 0.39 mm. and 0.59 mm. in width. A large deep fossa extends the full length of the jaw. The margins of the fossa are usually thin and broken.

Eunicites altinsculus resembles *Eunicites colossus* Eller (1945) in size and shape. The two species differ in the shape of the shank and fossa. A Silurian form from Gotland, *Arabellites uncinatus* Hinde, 1882, corresponds to *Eunicites altinsculus* rather closely.

***Eunicites acidaspis* sp. nov.**

Maxilla V. Plate 27, Fig. 12, 16-17

The jaw is a small, angular, subtriangular shaped, sharp-pointed single denticle. A large round or irregularly shaped fossa occupies the posterior end. The margin of the fossa is slightly thickened. The upper side of the jaw between the fossa and the anterior end is flattened or slightly concave. There seems to be a small ridge in the middle and a slightly raised rim around the margins. The figured specimen measures 0.38 mm. in length.

While *Eunicites acidaspis* resembles many other forms in a general way, the individual characteristics set it apart from any other described species.

***Eunicites absonus* sp. nov.**

Maxilla IV or V. Plate 27, Fig. 18-19

The jaw is the shape of a small hook. The posterior end is wide and irregular and shows no evidence of a fossa. The jaw becomes narrow at the mid-area, thickens gradually, and then terminates abruptly as a very sharp-pointed denticle. The figured specimen measures 0.38 mm. in length.

The posterior end of this rather incongruous specimen is thin and probably partly missing. There is a possibility that there might have been a small fossa present for the attachment of a muscle. At first it was thought that the hooked shape of the jaw might not be natural. The presence of a number of specimens in the collection, however, ruled out this possibility. *Eunicites absonus* does not correspond to any other form.

Genus STAUONEREISITES gen. nov.

The jaw is wide, subtriangular in outline, and usually short in length. A series of two or more denticles occupies the inner margin. The first denticle may be large and the remaining teeth small or large and uniform in size. The anterior margin is straight or curved and is usually extended to form a wide or narrow shank. From the denticle the inner margin often continues to form a rectangular, rounded or acute shank. The shank may be straight or curved outward. In most forms, the under side is concave. A deep to shallow fossa occupies the complete upper side. The margins of the fossa may be thickened or thin and broken.

Genotype. *Stauronereisites auriculatus* sp. nov.

Maxilla of the modern genus *Stauronereis* Verrill (1900), (Treadwell, 1921) resemble those of *Stauronereisites* in a general way. This is especially so in *Stauronereis rubra* Grube (Treadwell, 1921, p. 123, text figures 449, 450). In this modern form the maxilla is made up of a series of jaws similar to the radula of gastropods. Possibly the fossil form occurred in this manner and consisted of only one type of jaw. Formerly, the writer placed jaws of this kind in the genus *Eunicites*. The genotype, *Stauronereisites auriculatus*, *Eunicites tolmachoffi* Eller (1945) and three other new species, *Stauronereisites adversarius*, *Stauronereisites aequalis*, and *Stauronereisites abditivus*, described in this paper, are included in the new genus. With additional material and study *Ungulitis aculeatus* Stauffer (1933), *Eunicites* (?) *index* Eller (1944), *Oenonites parvulus* Hinde (1882), and *Leodicites caley* Eller (1944) might also be placed in the genus *Stauronereisites*.

***Stauronereisites auriculatus* sp. nov.**

Maxilla III. Plate 25, Fig. 14-15

The jaw is small, subrectangular in outline and measures from 0.43 mm. to 0.52 mm. in length. Two large, conical, sharp-pointed denticles are located at the anterior end of the inner margin. The first denticle is slightly larger than the second. From the denticles the inner margin continues and curves slightly backwards to form a large ear-like appendage or shank. A fossa is present on the upper side of the jaw and the upper posterior margin is extended to form a large rectangular shank.

Eunicites tolmachoffi Eller (1945) is similar to *Stauronereisites auriculatus* except for the number and length of the denticles and the length and shape of the posterior end. The shanks and shape of *Stauronereisites auriculatus* must have given the jaw considerable movability and muscular effectiveness.

***Stauronereisites adversarius* sp. nov.**

Maxilla III. Plate 25, Fig. 10-12

The jaw is small, angular and wedge shaped in outline. The figured specimens measure 0.4 mm. and 0.29 mm. in length and 0.23 mm. and 0.22 mm. in width, respectively. Along the inner margin there is a series of four or five small blunt, conical denticles that extend nearly to the posterior end. The first denticle may be slightly hooked and appears to be a continuation of the anterior margin. The denticles increase slightly in size to the third tooth and then decrease to the posterior one. A large fossa occupies about one-half of the upper surface of the jaw. The posterior margin is thin and is turned towards and lies before the denticles. The under side is highly convex while the upper side between the denticles and the fossa is slightly concave.

There is a general similarity between *Stauronereisites adversarius* and *Eunicites tolmachoffi* Eller (1945) but in detail the two species differ widely.

***Stauronereisites abditivus* sp. nov.**

Maxilla III, Plate 25, Fig. 13

The jaw is subtriangular in outline and measures 0.43 mm. in length and 0.48 mm. in width. A series of three or four conical, sharp-pointed denticles occupies the inner margin. The first denticle is slightly larger and appears to be a continuation of the lateral margins. The remaining denticles decrease in size posteriorly. The elongated anterior margin may be nearly straight or curved upward. It terminates in a long, heavy shank. The outer and inner margins are extended, with the extremities widely separated, and they are about equal in length to the anterior shank. Usually they are broken. A large, narrow fossa occupies the upper side including the shank.

Stauronereisites abditivus resembles *Eunicites tolmachoffi* Eller (1945) and *Stauronereisites adversarius* (Plate 25, Fig. 10-12) in a general way. They differ mostly in the length of the shank and the length of the inner margin.

Stauronereisites aequalis sp. nov.

Maxilla III. Plate 27, Fig. 33

The jaw is subrectangular in outline and the figured specimen measures 0.39 mm. in length and 0.28 mm. in width. A series of five small, conical, sharp-pointed denticles extends along the inner margin. The teeth are nearly uniform or equal in size and point inward. A large fossa occupies more than one-half the area of the jaw. It is on a plane nearly parallel to the upper surface of the jaw. The rim of the fossa is wide and extends well beyond the anterior margin to form a broad shank. The margin of the fossa is thin and broken in all specimens.

Eunicites tolmachoffi Eller 1945, and *Stauronereisites adversarius* (Plate 25, Fig. 10-12) are similar to *Stauronereisites aequalis* in a general way. They differ mostly in the position and shape of the fossa.

Genus UNGULITES Stauffer, 1933**Ungulites acutidactylus** sp. nov.

Maxilla III. Plate 25, Fig. 3-4

All specimens of this species are broken at the posterior end. The jaw consists of two straight, narrow, sharp, finger-like denticles that occupy the anterior margin. The lateral margins, including the denticles, taper anteriorly to form a triangularly shaped jaw. The first denticle is large while the second is small in comparison. The figured specimens measure 0.62 mm. and 0.55 mm. in length. There is probably about one-tenth of a millimeter missing from the posterior end. A large fossa occupies about one-half of the upper surface of the jaw.

Stauffer (1933) described a species, *Ungulites bicuspidatus* Stauffer that resembles *Ungulites acutidactylus* closely except for the shape and character of the denticles. Except for the width and outline of the jaw *Ungulites bifurcus* Eller (1945) is similar to *Ungulites acutidactylus*.

Ungulites arquatus sp. nov.

Maxilla III. Plate 25, Fig. 5-6

The jaw is wide, arched, and subtriangular in outline. The figured specimens measure 0.97 mm. and 0.79 mm. in length. Two long, conical, backward curved, sharp-pointed denticles occupy the inner margin. In some specimens the denticles are nearly the same length. Most of the upper side of the jaw is occupied by a large, deep fossa. The margins of the fossa are thin and usually broken.

Ungulites arquatus is similar to *Ungulites bifurcus* Eller (1945) except for the width of the jaw and length of the denticles. *Ungulites bicuspidatus* Stauffer (1933) resembles *Ungulites arquatus* in a general way but differs in the length of the denticles.

Ungulites agglomeratus sp. nov.

Maxilla III or IV. Plate 25, Fig. 7-9

The jaw is large, wide, and heavy in character. Two denticles, the first one large, the second small, are present on the anterior margin. A large,

rectangular fossa occupies the posterior end. The walls of the jaw are thick at the opening of the fossa. The under side of the jaw is concave while the upper side is highly convex. The figured specimen measures 0.99 mm. in length and 0.56 mm. in width.

There is a slight resemblance between *Eunicites divergens* Eller (1938) (Plate 29, Fig. 11) and *Ungulites agglomeratus*. In the residue a cluster or mass of six or more jaws of this species was found (Fig. 7-8) compressed so tightly together that it is difficult to determine the posterior margins. The jaws are in no way articulated in a natural position. In the modern genus *Stauronereis* Verrill, the maxillary apparatus is composed of two rows of toothed plates. The 30 or more jaws in each series vary little from each other. It is possible that the group of fossil jaws (Fig. 7) distributed in this manner, and consisting of one type of jaw, belong to a form similar to those found under the modern genus *Stauronereis*.

***Ungulites astrictus* sp. nov.**

Maxilla III. Plate 27, Fig. 20

The jaw is large, heavy and wide. The figured specimen measures 0.83 mm. in length and 1.31 mm. in width. A series of five conical, blunt denticles occupies the inner margin. The first and second denticles are extremely large and are followed by two closely compact teeth that are small in comparison. The under surface of the jaw is concave while the upper surface is convex. A narrow fossa occupies the complete outer side and part of the anterior end of the jaw. The margins of the fossa are broken so that it is not possible to determine the true nature of its shape.

Heavy jaws of this kind are not common among scolecodont fauna. Stauffer (1933) described a species, *Ungulites aculeatus*, of this type.

***Ungulites auctus* sp. nov.**

Maxilla III. Plate 27, Fig. 21

The jaw is large, roughly triangular in shape and about twice as wide as it is long. The figured specimen measures 0.54 mm. in length and 1.16 mm. in width. Two large, blunt denticles occupy the inner margin. The first denticle is very large and the second is about one-half its size. The under surface of the jaw is flattened or slightly concave. A large, wide fossa occupies the complete upper side of the jaw. Part of the margin of the fossa is thickened and rounded.

Due to the width of the jaw and the size and character of the denticles, *Ungulites auctus* does not resemble any other species of this genus very closely.

***Ungulites* sp. indet.**

Maxilla II. Plate 27, Fig. 22

This form, although broken and represented by only one specimen, seems worth mentioning. The jaw is large and measures at least 1.5 mm. in length. On the inner margin are three conical, sharp-pointed denticles. The first, which is broken, was probably large and forward directed. A large fossa

occupies the posterior area. It is difficult to know which way the specimen should be oriented. The figured position is based on the large denticle.

***Ungulites* sp. indet.**

Maxilla III. Plate 27, Fig. 24

The jaw is subrectangular in outline and the figured specimen measures 0.46 mm. in width. Along the inner margin, a series of five conical, blunt denticles is followed intermittently by a series of minute crenulations. The anterior margin is broken but enough of the jaw is preserved to determine that the jaw did not extend much beyond its present limit. Both the upper and lower surfaces of the jaw are irregularly convex and concave. A narrow fossa occupies more than one-half the upper side of the jaw. The margin of the fossa on the under side is thin and broken.

Since this form is represented by only one specimen which is also broken, specific identification will not be attempted. The specimen seems worth figuring because of the interesting character and arrangement of the denticles.

***Ungulites alcornis* sp. nov.**

Maxilla II. Plate 27, Fig. 29-30

The jaw is long and narrow. The figured specimen measures 0.34 mm. in width and 0.83 mm. in length. A series of three large, conical blunt- to sharp-pointed, forward directed denticles occupies the anterior end. The first denticle or fang is large and points nearly straight forward. The other two denticles are nearly the same size and are directed slightly inward. The upper surface of the jaw is convex except for a long groove that extends the length of the jaw. On the under surface a depressed area occurs posterior to the denticles. A fossa occupies the posterior end and part of the upper side of the jaw.

Except for some general features, this form is unlike other species of the genus. It is rather rare in the fauna.

***Ungulites attenuatus* sp. nov.**

Maxilla IV. Plate 27, Fig. 32

The jaw is subtriangular in shape and the figured specimen measures 0.43 mm. in length and 0.62 mm. in width. Along the inner margin is a series of three weak, small, conical, blunt denticles. The first denticle is the largest and it points directly inward. It is followed by two teeth that are nearly the same size and which are directed slightly backward. The under side of the jaw is flattened posteriorly and convex adjacent to the denticles. A large fossa occupies most of the upper side of the jaw. The margins of the fossa are thin and partly broken.

This form, with its denticles small as compared with the rest of the jaw, does not very closely resemble any other species.

Genus ANISOCERASITES gen. nov.

The jaw is arched and subrectangular in outline. A series of three or more sharp-pointed, triangular or cone-shaped denticles occupies the inner margin. From the long, wide or narrow, medial tooth, the denticles on each side decrease gradually or abruptly to the anterior and posterior ends. The denticles may be straight or curved and may be directed backward. A deep angularly shaped fossa occupies the upper side of the jaw.

Genotype. *Eunicites tanaodus* Eller

Annals of the Carnegie Museum, v. 27, p. 279, plate 29, Fig. 5-6.

Stauffer (1933) in his description of the genus *Ungulites* included jaws of this type. The genotype, *Ungulites bicuspidatus* Stauffer, consists of a "long, sharp, curving tooth, on one side of which is a single, closely set similar but smaller tooth." This form does not correspond, or seem to be related, to the species included in the new genus. The genotype, *Anisocerasites tanaodus* (Eller), *Ungulites tridentatus* Stauffer (1933), *Ungulites confertus* Eller (1945) and five new species, *Anisocerasites aspidodus*, *Anisocerasites acidentatus*, *Anisocerasites acanthophorus*, *Anisocerasites amplimarginatus*, and *Anisocerasites acicularis*, described in this paper, are included in the new genus. In the modern polychaete genus *Anisoceras* Grobe (1856) the jaws are arranged in a series made up of many identical jaws. The forms described under the genus *Anisocerasites* appear to be similar to those of *Anisoceras* and may have been also arranged in a like manner. Verrill (1900) showed that *Anisoceras* was preoccupied and proposed instead *Stauronereis*.

Anisocerasites aspidodus sp. nov.

Maxilla III. Plate 25, Fig. 16; Plate 27, Fig. 31

The jaw is sub-oval in outline and the width and length are about the same in the recovered specimens. The outer margins are broken which may shorten the jaw. The figured specimen measures 0.78 mm. in length and 0.85 mm. in width. Along the inner margin is a series of six conical, blunt, backward directed denticles that are arranged in a circular manner. The first and second denticles are small while the third is several times as large. The two anterior denticles seem to originate from the under side of the third denticle. The remaining denticles decrease in size to the posterior end. A large fossa occupies most of the upper side of the jaw.

The arrangement and character of the denticles differ from those of other species. There is a slight resemblance between *Anisocerasites tanaodus* (Eller) (1938) and *Anisocerasites aspidodus*.

Anisocerasites acidentatus sp. nov.

Maxilla III. Plate 25, Fig. 17-18; Plate 27, Fig. 25-26

Unbroken specimens are elongate and a figured specimen measures 0.83 mm. in length and 0.38 mm. in width. A series of five conical, blunt- or sharp-pointed denticles occupies the inner margin. The first and fifth denticles are small and very sharp pointed. The third denticle is usually the largest and is often blunt. In most specimens the second and fourth denticles

are intermediate in size. A large fossa occupies the posterior part of the jaw. Its true shape can not be determined since most of the specimens are broken or partly so. The upper side of the jaw is convex while the under side is slightly concave.

Anisocerasites aciedentatus is similar to *Anisocerasites confertus* (Eller) (1945) in general shape but differs in the arrangement of the denticles and concavity of the under side.

***Anisocerasites acanthophorus* sp. nov.**

Maxilla III. Plate 25, Fig. 19-20; Plate 27, Fig. 27-28

The jaw is elongate and broken specimens are more than twice as long as they are wide. Figured specimens measure 1.06 mm. and 0.99 mm. in length and 0.29 mm. and 0.35 mm. in width. A series of three sharp-pointed denticles occupies the inner margin. The first and third denticles are small while the middle denticle is large and hooked. A large fossa occupies the posterior end of the jaw. The upper and under surfaces of the jaw are irregularly convex.

Except for the size, number and arrangement of the denticles *Anisocerasites acanthophorus* is similar to other species of the genus. There is a close resemblance between *Anisocerasites acanthophorus* and *Anisocerasites tridentus* (Stauffer) (1933). The length of the jaw and the middle denticle differ in the two species.

***Anisocerasites amplimarginatus* sp. nov.**

Maxilla III. Plate 25, Fig. 21

The jaw is thick and subtriangular in outline. On the curved inner margin a series of seven blunt, conical denticles extends the full length of the jaw. The first denticle is minute, and the second somewhat larger, while the third is very large in size. The remaining denticles decrease rapidly in size to the posterior end. A large, deep, rounded fossa occupies most of the upper surface of the jaw. The margins of the fossa are thickened and rounded. The anterior margin is long and straight and forms a large shank with the incurved outer margin. The figured specimen measures 0.59 mm. in length and 1.3 mm. in width.

Anisocerasites amplimarginatus is very similar to *Anisocerasites tanaodus* (Eller) (1938). They differ in the curvature of the inner and anterior margins, the shape of the fossa and the general character of the denticles.

***Anisocerasites tanaodus* (Eller)**

Maxilla. Plate 26, Fig. 1-4

Eunicites tanaodus Eller, 1938, Annals of the Carnegie Museum, v. 27, p. 279, plate 29, Fig. 5-6.

The fauna contains a number of specimens of this species. There is a similarity between *Anisocerasites tanaodus* (Eller), *Anisocerasites amplimarginatus* and *Anisocerasites aspidodus*. The opening of the fossa of *Anisocerasites tanaodus* (Eller) is in the same plane as the denticles. This gives an abrupt inward curvature to the upper surface between the fossa and the denticles. Jaws with a large medial tooth and smaller teeth on each side

are not common in scolecodont faunas. In some species of the recent polychaete genus *Stauronerus* Verrill (1900) (*Anisoceras* Grobe, 1856), two rows of about thirty jaws each of this type are found arranged in a series. It is possible that the fossil jaws belong to this type of maxillary apparatus. The fossil jaws are very large as compared with the modern forms. The figured specimens measure from 0.33 mm. to 0.75 mm. in length and from 0.46 mm. to 1.11 mm. in width.

***Anisocerasites acicularis* sp. nov.**

Maxilla. Plate 26, Fig. 5-6

The jaw is large and irregular in outline. A series of six, large, conical, sharp-pointed denticles extends the full length of the inner margin. The second and third denticles are very large and the denticles on each side decrease in size to the anterior and posterior margin. A large irregularly shaped fossa occupies the posterior and part of the upper surface of the jaw. The opening of the fossa is not in the same plane as the denticles. The under surface is extended to form a shank. The posterior margin is thin and broken. The figured specimen measures 0.78 mm. in length and 0.89 mm. in width.

Anisocerasites acicularis is similar to *Eunicites? index* Eller (1944) in a general way. The length and arrangement of the denticles are different and the area between the fossa and the denticles on the upper side is not the same. There is a resemblance between *Anisocerasites acicularis* and *Anisocerasites tanaodus* (Eller) (1938). They differ in the size and arrangement of the denticles and the plane in which the fossa opens.

***Anisocerasites validus* (Eller)**

Maxilla. Plate 26, Fig. 7-8; Plate 27, Fig. 34-35

Eunicites validus Eller, 1938, Annals of the Carnegie Museum, v. 27, p. 279, plate 29, Fig. 4.

A large number of specimens are present in the fauna. A left jaw was figured in the original description. The right and left jaws illustrated in this paper are similar except for the denticles which vary in length. The figured specimens measure from 0.45 mm. to 0.99 mm. in length.

Genus DIOPATRAITES Eller, 1938

***Diopatraites asper* sp. nov.**

Mandible. Plate 26, Fig. 10

The right mandible is elongate with a short, narrow, sharp-pointed shaft. The figured specimen, although broken, measures about 0.83 mm. in length. The inner margin is nearly straight and shows a ridge for articulation with the left mandible. Only a fragment of the left mandible is present and due to poor preservation it is not possible to follow the split between the two mandibles. The surface of the mandible is irregular in contour. The posterior end is incurved from the inner margin to form the shaft.

Diopatraites asper is similar to *Diopatraites diplexus* Eller (1945) except for the posterior end and shaft. The same is true of a number of species described by Eisenack (1939).

Diopatraites abruptus sp. nov.

Mandible. Plate 26, Fig. 11

The right mandible is narrow and elongate. Taking into consideration that the specimen is broken at the anterior end, the length would measure about 0.55 mm. Its width is about 0.16 mm. The inner margin of the plate is irregularly curved and shows evidence of structures for articulation. The outer margin is slightly broken or ragged but close examination suggests that very little of the plate is missing. The posterior end is slightly incurved and forms an abrupt, wide, sharp-pointed shaft. The surface of the mandible is irregularly convex and concave.

Diopatraites abruptus is so unlike any other species that comparisons are not feasible. It differs in the narrowness of the plate and the shortness and width of the shaft.

Diopatraites arctostriatus sp. nov.

Mandible. Plate 26, Fig. 12, 16-17

The mandible is long, angular, and slightly curved. Measurements of specimens is difficult since the posterior end is usually broken. An average specimen would measure about 0.85 mm. in length. The frontal plate is small, convex and oval in outline. At the anterior end are three teeth which decrease in size from the inner margin. The surface of the plate is ornamented with very fine striations. The shaft is long, slightly curved, and in most specimens as wide as the frontal plate. The upper surface is highly angular while the under side is deeply concave. The shaft decreases in size very gradually and terminates in a blunt posterior end.

In the form of the mandible, *Diopatraites arctostriatus* does not resemble any other species very closely. The number of teeth of *Diopatraites conformis* Eller (1938) is the same but otherwise the forms are dissimilar.

Diopatraites alveatus sp. nov.

Mandible. Plate 26, Fig. 13-14

Measurements of the mandible are not possible since only broken specimens were found. An average specimen is estimated to be 0.75 mm. in length. The frontal plate is small, oval in outline, and connected obliquely with the shaft at about a forty-five-degree angle. The surface is irregular concave and convex. Two conical teeth are present at the anterior end of the plate. The shaft is long in comparison with the size of the plate. It tapers gradually to a pointed posterior extremity. The upper side is highly convex while the under side is deeply concave or hollowed out.

Diopatraites alveatus is similar to *Diopatraites fustes* Eller (1942), *Diopatraites conformis* Eller (1938), and *Palaeosigma silurica* Eisenack (1939) in their general characteristics. They differ in the number of denticles and the shape and length of the shaft.

Diopatraites aequilaterus sp. nov.

Mandible. Plate 26, Fig. 15

The left mandible is nearly triangular in outline and tapers from a wide

posterior to an acutely pointed anterior end. The inner margin is slightly incurved and on the under side shows evidence of having fitted over the right plate. Along the nearly straight outer margin at about the middle is a well pronounced ridge. The posterior margin is broadly incurved to form a wide, long truncate shaft. The upper surface of the mandible is mostly convex except near the ridge on the outer margin and on the shaft. Measurements of the figured specimen are 0.7 mm. in length and 0.24 mm. in width.

An acute anterior end has not been found in other species of *Diopatraites*. The posterior end and shaft, however, are similar to other forms of the genus.

***Diopatraites aversus* sp. nov.**

Mandible. Plate 26, Fig. 18-20.

Measurements of the mandible range from 0.57 mm. to about 1.5 mm. in length. The frontal plate is large, heavy, and oval in outline. The upper surface of the plate is irregularly convex and concave. At the posterior end the plate turns away abruptly to nearly a forty-five-degree angle and continues to an acute end. The shaft is very short, about two-thirds the length of the plate. It is triangular in cross-section. The frontal plate and the shaft are not set at an appreciable angle with each other but are nearly straight.

Mandibles of this type are common in the fauna, but the anterior and posterior ends are usually broken. *Diopatraites aversus* is similar to *Diopatraites fustis* Eller (1942) and *Palaeosigma silurica* Eisenack (1939). They differ in the length of the shaft and the angle at which the frontal plate and the shaft are joined.

***Diopatraites accommodus* sp. nov.**

Mandible. Plate 26, Fig. 21

The left mandible is large and wide, and the figured specimen measures 1.62 mm. in length. The inner margin is straight and a groove on the under surface suggests that it would accommodate and articulate a right mandible. Except along the inner margin the surface is slightly concave. At the posterior end the margin incurves gently to form a long, wide, sharp-pointed shaft. The shaft is concave on the upper surface, and slightly convex on the under side.

Diopatraites accommodus does not very closely resemble any other species. Eisenack (1939) described a form, *Siluropella triangula*, that has some resemblance. They differ in the length and width of the plate and the length of the shaft.

***Diopatraites conformis* Eller**

Mandible. Plate 26, Fig. 22

Diopatraites conformis Eller, 1938, Annals of the Carnegie Museum, v. 27, p. 282-283, plate 29, Fig. 12-15.

The figured specimen is complete and well illustrates a left mandible. There are slight variations in the arrangement of the teeth and the shape

of the shaft of this specimen as compared with the originally described forms. The first denticle is larger than the two following while in the originally described specimens the middle denticle is largest and all denticles have large spaces between them. Perhaps the characters constitute specific differences but the writer hesitates to erect a new species without a larger series of specimens for study.

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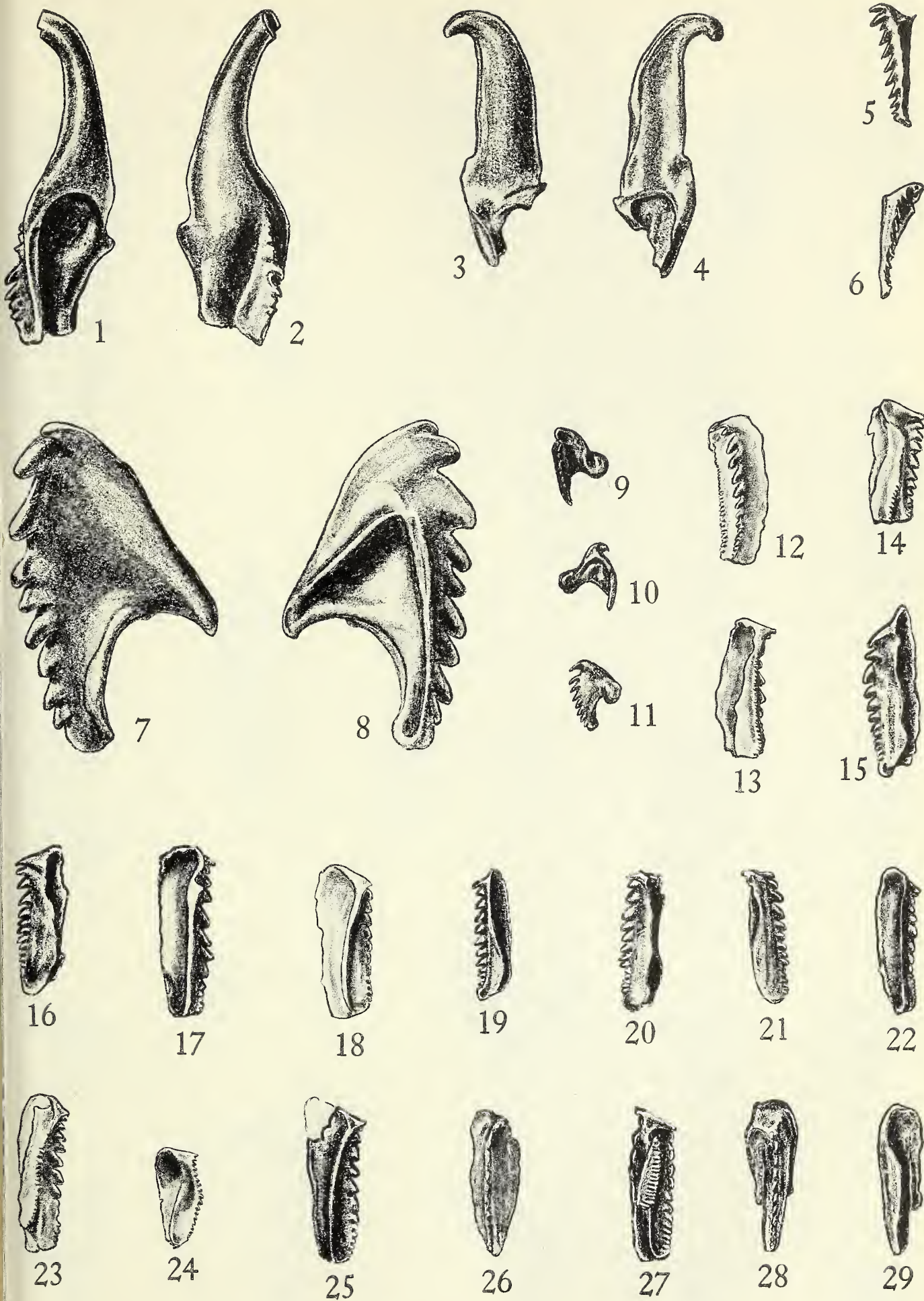
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EXPLANATION OF PLATE 22

Figures magnified about 28 times

Numbers in parentheses indicate the Carnegie Museum catalogue numbers of the respective type specimens.

- FIG. 1-2. *Arabellites arrectus* sp. nov.
Maxilla I, right jaw (27862).
Fig. 1. Upper side.
Fig. 2. Under side.
- FIG. 3-4. *Nereidavus angulatus* (Eller)
Maxilla I, left jaw (27865).
Fig. 3. Under side.
Fig. 4. Upper side.
- FIG. 5-6. *Leodicites angiformis* sp. nov.
Maxilla II, right jaw (27869).
Fig. 5. Upper side.
Fig. 6. Under side.
- FIG. 7-8. *Leodicites altilis* sp. nov.
Maxilla II, left jaw (27870).
Fig. 7. Under side.
Fig. 8. Upper side.
- FIG. 9-11. *Leodicites abbreviatus* sp. nov.
Maxilla II, left jaw (27873).
Fig. 9. Under side.
Fig. 10. Upper side.
Fig. 11. Side view.
- FIG. 12-13. *Staurocephalites aequilateralis* sp. nov.
Maxilla II, left jaw (27874).
Fig. 12. Under side.
Fig. 13. Upper side.
- FIG. 14. *Staurocephalites aequilateralis* sp. nov.
Maxilla II, left jaw (27877).
- FIG. 15. *Staurocephalites aequilateralis* sp. nov.
Maxilla II, right jaw (27878).
- FIG. 16. *Staurocephalites aequilateralis* sp. nov.
Maxilla II, right jaw (27882).
- FIG. 17. *Staurocephalites aequilateralis* sp. nov.
Maxilla II, left jaw (27888).
- FIG. 18. *Staurocephalites aequilateralis* sp. nov.
Maxilla, left jaw (27892).
- FIG. 19. *Staurocephalites aequilateralis* sp. nov.
Maxilla II, right jaw (27898).
- FIG. 20-21. *Staurocephalites aequilateralis* sp. nov.
Maxilla II, right jaw (27904).
Fig. 20. Upper side.
Fig. 21. Under side.
- FIG. 22. *Staurocephalites aequilateralis* sp. nov.
Maxilla II, left jaw (27910).
- FIG. 23. *Staurocephalites aequilateralis* sp. nov.
Maxilla II, left jaw (27916).
- FIG. 24. *Staurocephalites aequilateralis* sp. nov.
Maxilla III, left jaw (27917).
- FIG. 25. *Staurocephalites aequilateralis* sp. nov.
Maxilla II, left jaw (27918).
- FIG. 26. *Staurocephalites aequilateralis* sp. nov.
Maxilla II, left jaw (27924).
- FIG. 27-29. *Staurocephalites aequilateralis* sp. nov.
Maxilla II, left jaw (27926).
Fig. 27. Upper side.
Fig. 28. Under side.
Fig. 29. Side view.

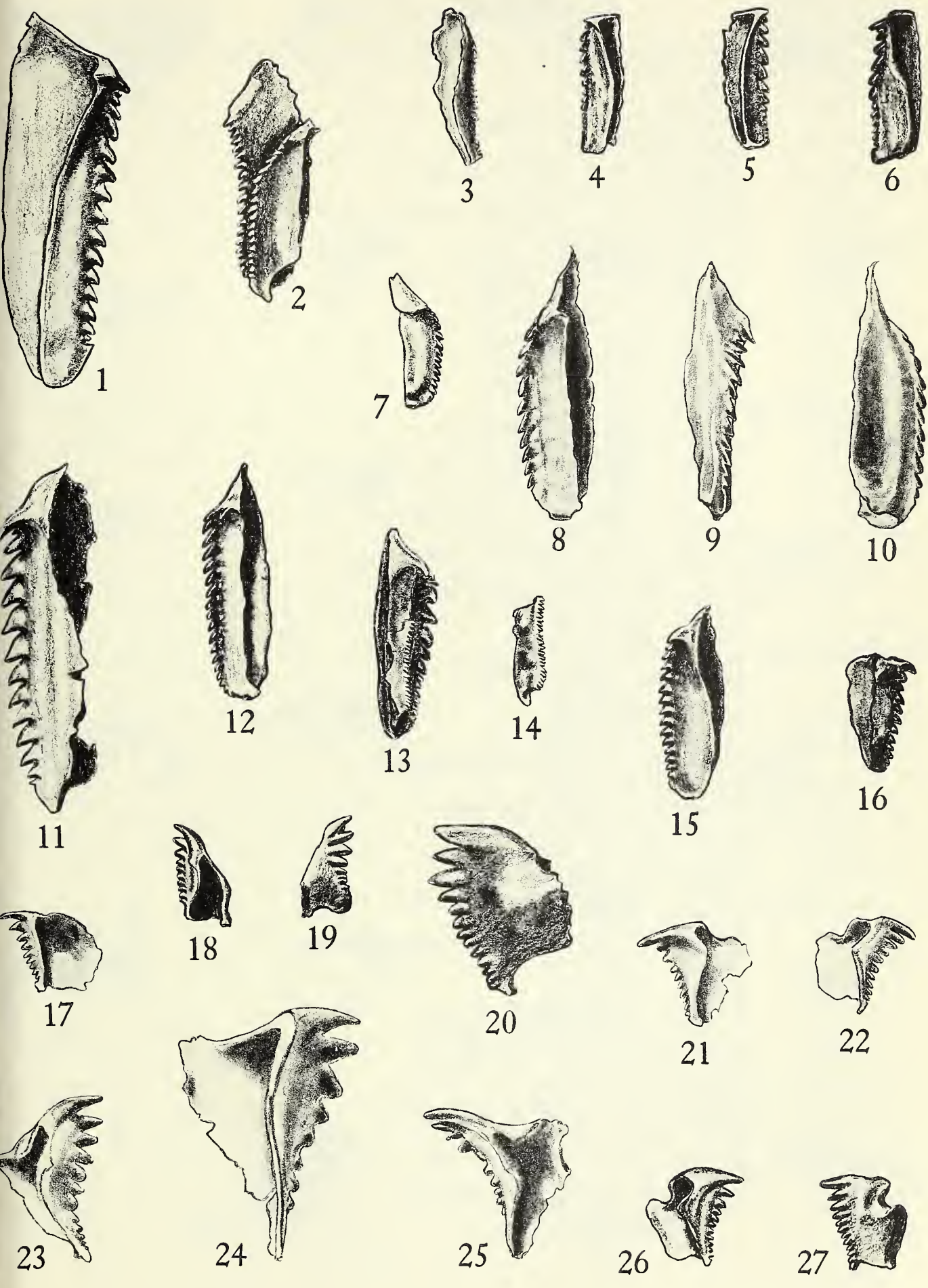


EXPLANATION OF PLATE 23

Figures magnified about 28 times

Numbers in parentheses indicate the Carnegie Museum catalogue numbers of the respective type specimens.

- FIG. 1. *Staurocephalites articulatus* sp. nov.
Maxilla II, left jaw (27783).
- FIG. 2. *Staurocephalites articulatus* sp. nov.
Maxilla II, III, left jaw (27784).
- FIG. 3. *Staurocephalites articulatus* sp. nov.
Maxilla III, left jaw (27785).
- FIG. 4. *Staurocephalites aequemarginalis* sp. nov.
Maxilla II, right jaw (27795).
- FIG. 5. *Staurocephalites aequemarginalis* sp. nov.
Maxilla II, left jaw (27796).
- FIG. 6. *Staurocephalites aequemarginalis* sp. nov.
Maxilla II, right jaw (27797).
- FIG. 7. *Staurocephalites articulatus* sp. nov.
Maxilla III, right jaw (27932).
- FIG. 8-10. *Staurocephalites alterostris* sp. nov.
Maxilla II, right jaw (27807).
Fig. 8. Upper side.
Fig. 9. Side view.
Fig. 10. Under side.
- FIG. 11. *Staurocephalites alterostris* sp. nov.
Maxilla II, right jaw (27808).
- FIG. 12. *Staurocephalites alterostris* sp. nov.
Maxilla II, right jaw (27809).
- FIG. 13-14. *Staurocephalites alterostris* sp. nov.
Maxilla II, III, left jaw (27810).
Fig. 13. Upper side.
Fig. 14. Maxilla III, upper side.
- FIG. 15. *Staurocephalites alterostris* sp. nov.
Maxilla II, right jaw (27811).
- FIG. 16. *Oenonites aequibrachiatus* sp. nov.
Maxilla II, left jaw (27926).
- FIG. 17. *Paleoenonites auctificus* sp. nov.
Maxilla II, right jaw (27828).
- FIG. 18-19. *Oenonites abscisus* sp. nov.
Maxilla I, right jaw (27827).
Fig. 18. Upper side.
Fig. 19. Under side.
- FIG. 20. *Paleoenonites angiportus* sp. nov.
Maxilla II, left jaw (27831).
- FIG. 21. *Paleoenonites angiportus* sp. nov.
Maxilla II, right jaw (27832).
- FIG. 22. *Paleoenonites angiportus* sp. nov.
Maxilla II, left jaw (27833).
- FIG. 23. *Paleoenonites armigerus* sp. nov.
Maxilla II, left jaw (27845).
- FIG. 24. *Paleoenonites alpenaensis* (Eller).
Maxilla II, left jaw (27853).
- FIG. 25. *Paleoenonites armigerus* sp. nov.
Maxilla II, right jaw (27846).
- FIG. 26-27. *Paleoenonites angiportus* sp. nov.
Maxilla II, left jaw (27834).
Fig. 26. Upper side.
Fig. 27. Under side.

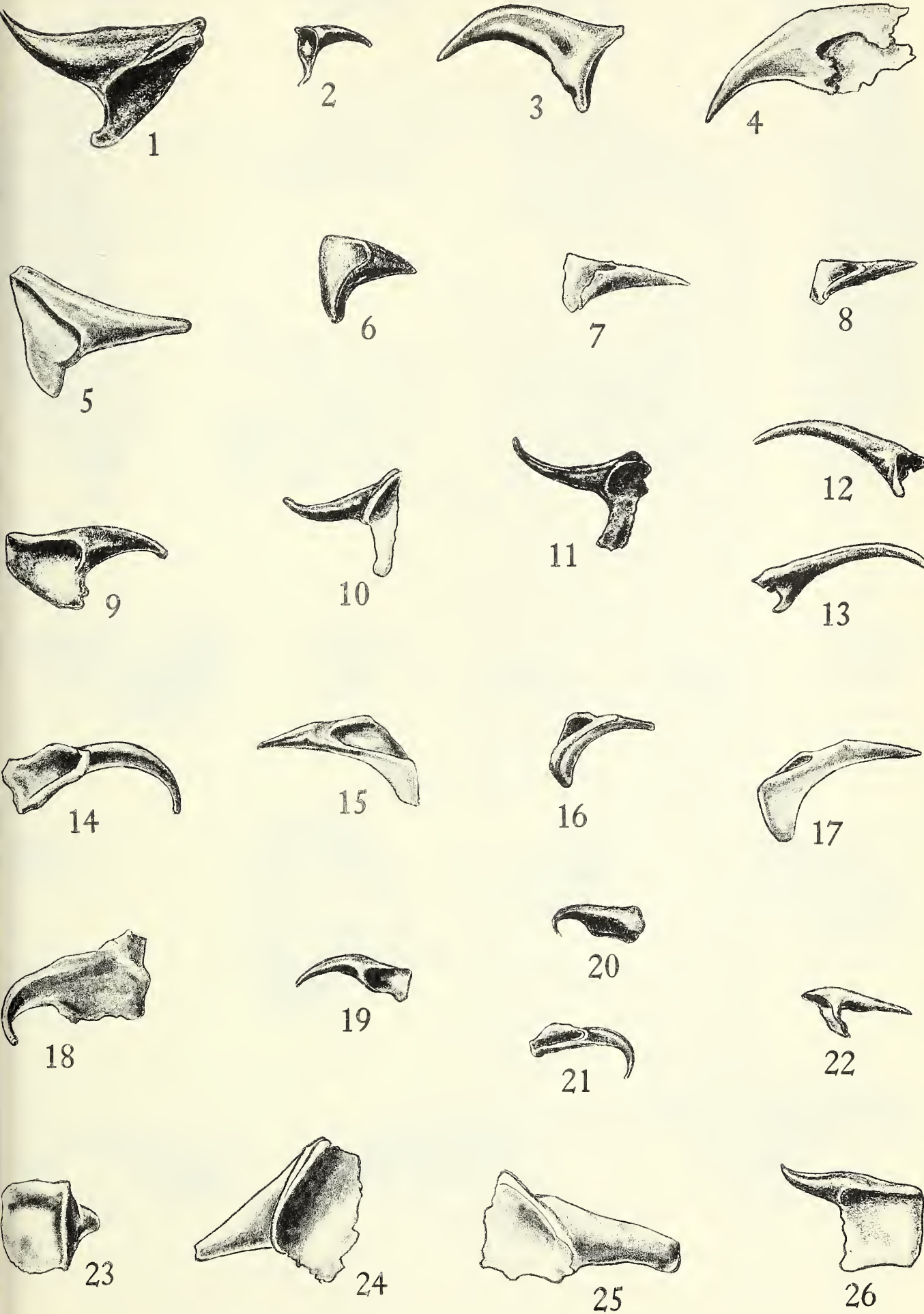


EXPLANATION OF PLATE 24

Figures magnified about 28 times

Numbers in parentheses indicate the Carnegie Museum catalogue numbers of the respective type specimens.

- FIG. 1. *Eunicites apicalis* sp. nov.
Maxilla IV, right jaw (27688).
- FIG. 2. *Eunicites adicus* sp. nov.
Maxilla IV or V, left jaw (27694).
- FIG. 3. *Eunicites alveolaris* sp. nov.
Maxilla IV or V, right jaw (27696).
- FIG. 4. *Eunicites asaphus* sp. nov.
Maxilla IV, right jaw (27699).
- FIG. 5. *Eunicites altidorsalis* sp. nov.
Maxilla IV, left jaw (27702).
- FIG. 6. *Eunicites acutirostris* sp. nov.
Maxilla V, left jaw (27704).
- FIG. 7. *Eunicites apidodus* sp. nov.
Maxilla V, left jaw (27711).
- FIG. 8. *Eunicites apidodus* sp. nov.
Maxilla V, left jaw (27712).
- FIG. 9. *Eunicites admirandus* sp. nov.
Maxilla IV or V, left jaw (27719).
- FIG. 10. *Eunicites anquisitus* sp. nov.
Maxilla IV or V, right jaw (27724).
- FIG. 11. *Eunicites anquisitus* sp. nov.
Maxilla IV or V, right jaw (27725).
- FIG. 12-13. *Eunicites acinaciformis* sp. nov.
Maxilla IV or V, right jaw (27726).
Fig. 12. Upper side.
Fig. 13. Under side.
- FIG. 14, 18. *Eunicites articulosus* sp. nov.
Maxilla IV, left jaw (27732).
Fig. 14. Upper side.
Fig. 18. Under side.
- FIG. 15. *Eunicites apiculatus* sp. nov.
Maxilla IV or V, right jaw (27737).
- FIG. 16. *Eunicites apiculatus* sp. nov.
Maxilla IV or V, left jaw (27738).
- FIG. 17. *Eunicites apiculatus* sp. nov.
Maxilla IV or V, left jaw (27739).
- FIG. 19. *Eunicites articulosus* sp. nov.
Maxilla IV or V, right jaw (27733).
- FIG. 20-21. *Eunicites articulosus* sp. nov.
Maxilla IV or V, right jaw (27734).
Fig. 20. Under side.
Fig. 21. Upper side.
- FIG. 22. *Eunicites acutulus* sp. nov.
Maxilla IV or V, left jaw (27743).
- FIG. 23. *Eunicites ambocoelius* sp. nov.
Maxilla IV or V, left jaw (27746).
- FIG. 24. *Eunicites conus* (Eller).
Maxilla IV or V, right jaw (27748).
- FIG. 25. *Eunicites conus* (Eller).
Maxilla IV or V, left jaw (27749).
- FIG. 26. *Eunicites axinus* sp. nov.
Maxilla IV or V, right jaw (27752).

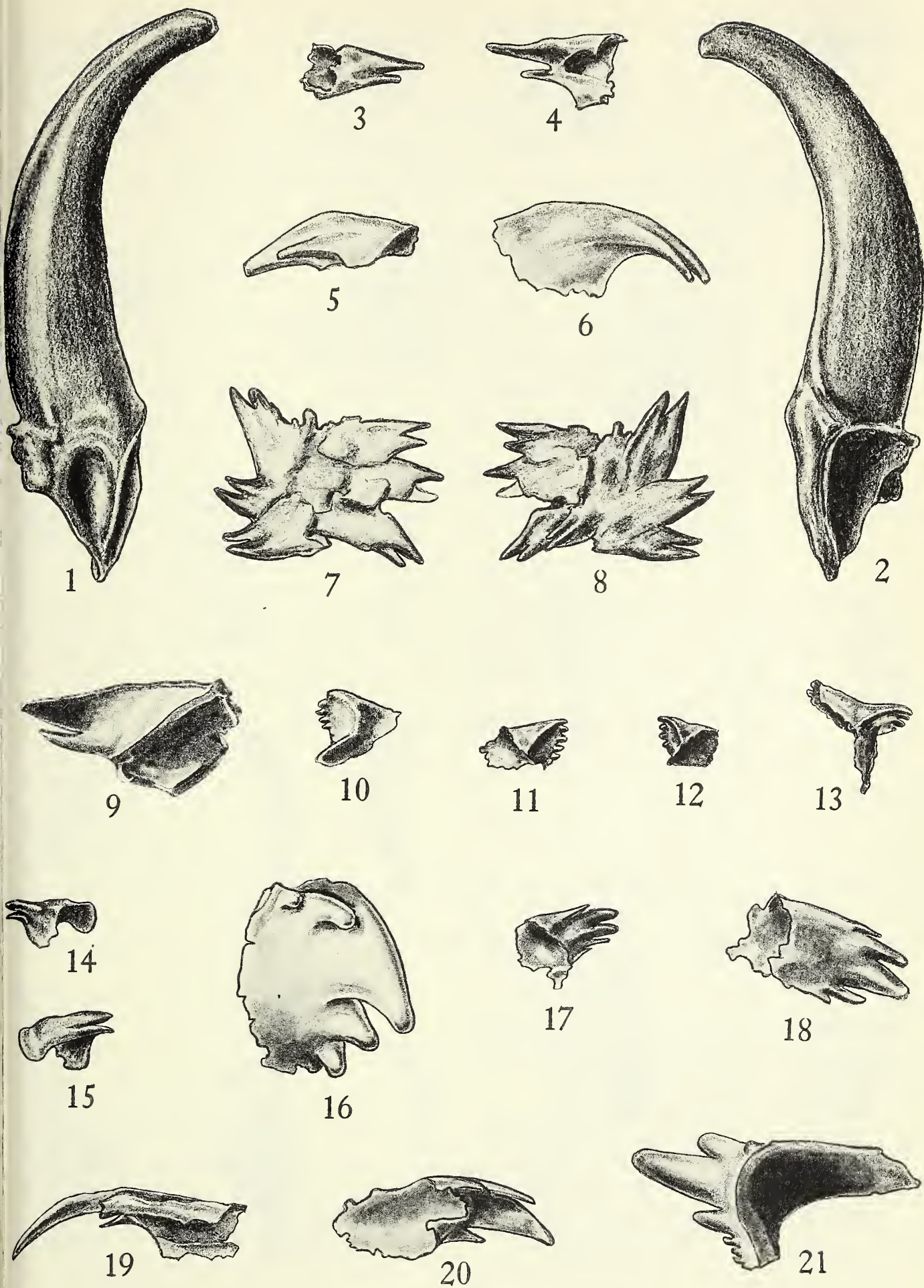


EXPLANATION OF PLATE 25

Figures magnified about 28 times

Numbers in parentheses indicate the Carnegie Museum catalogue numbers of the respective type specimens.

- FIG. 1-2. *Eunicites angulatus* Eller.
Maxilla I, right jaw (27756).
Fig. 1. Under side.
Fig. 2. Upper side.
- FIG. 3. *Ungulites acutidactylus* sp. nov.
Maxilla III, left jaw (27757).
- FIG. 4. *Ungulites acutidactylus* sp. nov.
Maxilla III, right jaw (27758).
- FIG. 5. *Ungulites arquatus* sp. nov.
Maxilla III, left jaw (27759).
- FIG. 6. *Ungulites arquatus* sp. nov.
Maxilla III, right jaw (27760).
- FIG. 7-8. *Ungulites agglomeratus* sp. nov.
Maxilla, obverse, reverse (27762).
- FIG. 9. *Ungulites agglomeratus* sp. nov.
Maxilla, right jaw (27763).
- FIG. 10. *Stauronereisites adversarius* sp. nov.
Maxilla III, right jaw (27765).
- FIG. 11. *Stauronereisites adversarius* sp. nov.
Maxilla III, left jaw (27766).
- FIG. 12. *Stauronereisites adversarius* sp. nov.
Maxilla III, right jaw (27767).
- FIG. 13. *Stauronereisites abditivus* sp. nov.
Maxilla III, left jaw (27768).
- FIG. 14-15. *Stauronereisites auriculatus* sp. nov.
Maxilla III, right jaw (27769).
Fig. 14. Upper side.
Fig. 15. Under side.
- FIG. 16. *Anisocerasites aspidodus* sp. nov.
Maxilla III, right jaw (27931).
- FIG. 17. *Anisocerasites aciedentatus* sp. nov.
Maxilla III, left jaw (27772).
- FIG. 18. *Anisocerasites aciedentatus* sp. nov.
Maxilla III, left jaw? (27773).
- FIG. 19. *Anisocerasites acanthophorus* sp. nov.
Maxilla III, right jaw (27776).
- FIG. 20. *Anisocerasites acanthophorus* sp. nov.
Maxilla III, left jaw (27777).
- FIG. 21. *Anisocerasites amplimarginatus* sp. nov.
Maxilla III, right jaw (27996).

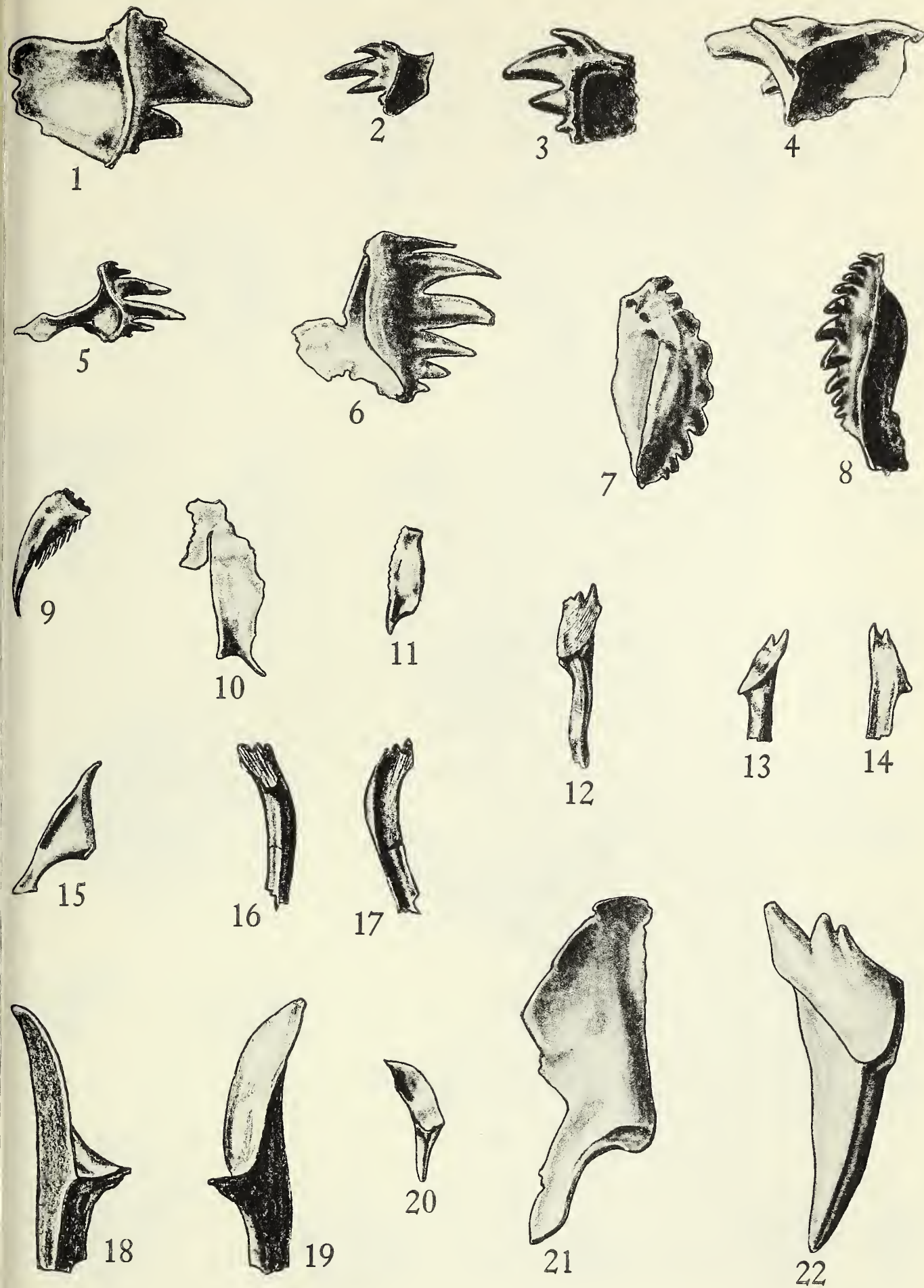


EXPLANATION OF PLATE 26

Figures magnified about 28 times

Numbers in parentheses indicate the Carnegie Museum catalogue numbers of the respective type specimens.

- FIG. 1. *Anisocerasites tanaodus* (Eller).
Maxilla, left jaw (27670).
- FIG. 2. *Anisocerasites tanaodus* (Eller).
Maxilla, right jaw (27671).
- FIG. 3. *Anisocerasites tanaodus* (Eller).
Maxilla, right jaw (27672).
- FIG. 4. *Anisocerasites tanaodus* (Eller).
Maxilla, right jaw (27673).
- FIG. 5. *Anisocerasites acicularis* sp. nov.
Maxilla, left jaw (27679).
- FIG. 6. *Anisocerasites acicularis* sp. nov.
Maxilla, left jaw (27680).
- FIG. 7. *Anisocerasites validus* (Eller).
Maxilla, left jaw (27681).
- FIG. 8. *Anisocerasites validus* (Eller).
Maxilla, right jaw (27682).
- FIG. 9. *Eunicites? alienus* sp. nov.
Maxilla? right jaw? (27683).
- FIG. 10. *Diopatraites asper* sp. nov.
Mandible, right shaft (27656).
- FIG. 11. *Diopatraites abruptus* sp. nov.
Mandible, left shaft (27654).
- FIG. 12. *Diopatraites arctostriatus* sp. nov.
Mandible, right shaft (27646).
- FIG. 13-14. *Diopatraites alveatus* sp. nov.
Mandible, right shaft (27653).
Fig. 13. Upper side.
Fig. 14. Under side.
- FIG. 15. *Diopatraites aequilaterus* sp. nov.
Mandible, left shaft (27645).
- FIG. 16-17. *Diopatraites arctostriatus* sp. nov.
Mandible, left shaft (27647).
Fig. 16. Upper side.
Fig. 17. Under side.
- FIG. 18-19. *Diopatraites aversus* sp. nov.
Mandible, right shaft (27659).
Fig. 18. Under side.
Fig. 19. Upper side.
- FIG. 20. *Diopatraites aversus* sp. nov.
Mandible, left shaft (27660).
- FIG. 21. *Diopatraites accommodus* sp. nov.
Mandible, left shaft (27641).
- FIG. 22. *Diopatraites conformis* Eller.
Mandible, left shaft (27667).



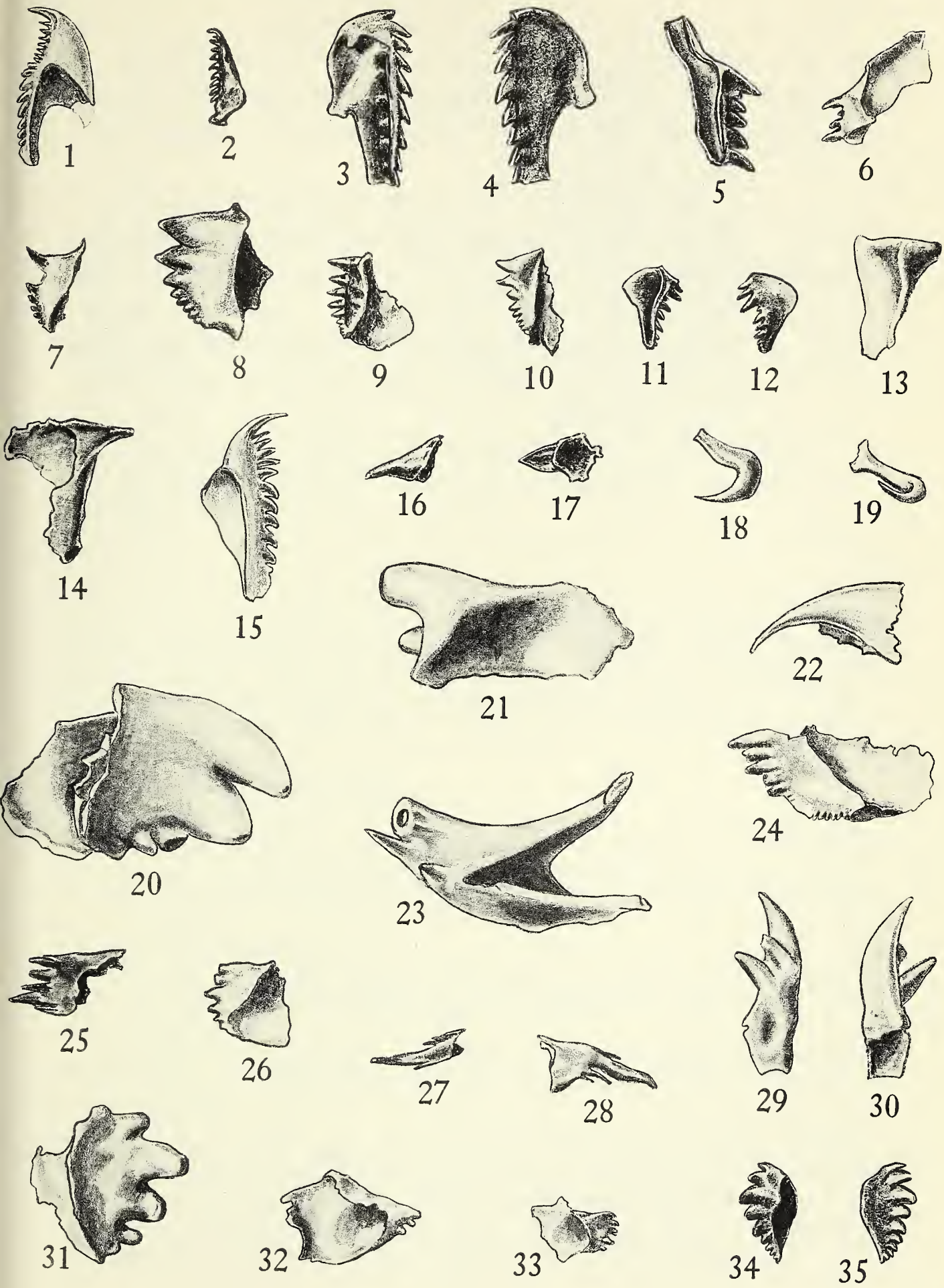
EXPLANATION OF PLATE 27

Figures magnified about 28 times

Numbers in parentheses indicate the Carnegie Museum catalogue numbers of the respective type specimens.

- FIG. 1. *Ildraites appressus* sp. nov.
Maxilla II, right jaw (27939).
- FIG. 2. *Nereidavus? admixtus* sp. nov.
Maxilla I, right jaw (27940).
- FIG. 3-4. *Leodicites amplicameratus* sp. nov.
Maxilla II, left jaw (27941).
Fig. 3. Upper side.
Fig. 4. Under side.
- FIG. 5. *Leodicites ambiguus* sp. nov.
Maxilla II, left jaw (27947).
- FIG. 6. *Leodicites ambiguus* sp. nov.
Maxilla, right jaw (27948).
- FIG. 7. *Leodicites angusticameratus* sp. nov.
Maxilla II, right jaw (27950).
- FIG. 8. *Paleoenonites andaculus* sp. nov.
Maxilla II, right jaw (27954).
- FIG. 9. *Paleoenonites andaculus* sp. nov.
Maxilla II, right jaw (27958).
- FIG. 10. *Paleoenonites andaculus* sp. nov.
Maxilla II, right jaw (27961).
- FIG. 11-12. *Paleoenonites arcuatellus* sp. nov.
Maxilla II, left jaw (27962).
Fig. 11. Upper side.
Fig. 12. Under side.
- FIG. 13. *Eunicites altinsculus* sp. nov.
Maxilla IV or V, left jaw (27965).
- FIG. 14. *Eunicites altinsculus* sp. nov.
Maxilla IV or V, left jaw (27966).
- FIG. 15. *Oenonites orthodontus?* Eller.
Maxilla I, left jaw (27933).
- FIG. 16-17. *Eunicites acidaspis* sp. nov.
Maxilla V, right jaw (27967).
Fig. 16. Side view.
Fig. 17. Upper side.
- FIG. 18-19. *Eunicites absonus* sp. nov.
Fig. 18. Side view.
Fig. 19. Under side.
- FIG. 20. *Ungulites astrictus* sp. nov.
Maxilla III, left jaw (27969).
- FIG. 21. *Ungulites auctus* sp. nov.
Maxilla III, right jaw (27970).
- FIG. 22. *Eunicites asaphus* sp. nov.
Maxilla IV, right jaw (27974).
- FIG. 23. *Ungulites* sp. indet.
Maxilla II, right jaw? (27972).
- FIG. 24. *Ungulites* sp. indet.
Maxilla III, right jaw (27973).
- FIG. 25. *Anisocerasites aciedentatus* sp. nov.
Maxilla III, right jaw (27975).
- FIG. 26. *Anisocerasites aciedentatus* sp. nov.
Maxilla III, right jaw (27976).

CONTINUED ON PAGE 386



- FIG. 27. *Anisocerasites acanthophorus* sp. nov.
Maxilla III, right jaw (27977).
- FIG. 28. *Anisocerasites acanthophorus* sp. nov.
Maxilla III, left jaw (27978).
- FIG. 29-30. *Ungulites alicornis* sp. nov.
Maxilla II, left jaw (27980).
Fig. 29. Under side.
Fig. 30. Upper side.
- FIG. 31. *Anisocerasites aspedodus* sp. nov.
Maxilla III, left jaw (27982).
- FIG. 32. *Ungulites attenuatus* sp. nov.
Maxilla IV, left jaw (27983).
- FIG. 33. *Stauronereisites aequalis* sp. nov.
Maxilla, left jaw (27991).
- FIG. 34-35. *Anisocerasites validus* (Eller).
Maxilla II, right jaw (27984).
Fig. 34. Upper side.
Fig. 35. Under side.

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Art. 22

POPULAR SUMMARY

Another new bird has resulted from Carnegie Museum's bird explorations in Honduras, which have been supported by the Matthew T. Melion Foundation.

This previously unrecognized black hawk is apparently confined to the mangrove swamps of Utila Island, 18 miles off the north coast of Honduras. The big birds are locally known as 'crab hawks' because they feed extensively upon the abundant land crabs, although they eat iguanas as well.

The price of additional copies of this publication, obtainable at Carnegie Museum, Pittsburgh 13, Pa., is 15¢.

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ART. 22. A NEW RACE OF BLACK HAWK OF THE SPECIES
BUTEOGALLUS ANTHRACINUS FROM THE REPUBLIC OF
HONDURAS

BY ARTHUR C. TWOMEY
Curator of Birds

In Carnegie Museum, the Section of Birds has, since 1947, been conducting a comprehensive survey of the bird life of the Republic of Honduras, and will continue until that country has been adequately covered. This extensive field work has been made possible through the generous and continued support of Dr. Matthew T. Mellon and the Matthew T. Mellon Foundation.

During my preliminary studies of the Honduras collections I have discovered a distinct new race of *Buteogallus anthracinus*, which I propose to name as follows:

Buteogallus anthracinus utilensis, subsp. nov. Utila Crab Hawk.

Type. Carnegie Museum Collection, no. 132,774, adult female; Isla Utila, Bay Islands, Republic of Honduras, April 24, 1948; Arthur C. Twomey, original number 13,190.

Subspecific characters. Similar to *Buteogallus anthracinus anthracinus* (Lichtenstein), but plumage uniformly more fuscous (less black), and the feathers of the lower back, wings, lower breast and belly tipped with pale bone brown. The grayish-white mottling of the bases of the two outermost primaries typical of *B. a. anthracinus* is wholly lacking or partially indicated in *B. a. utilensis*. The inner webs of the outer secondaries are mottled with gray instead of the rufous of *B. a. anthracinus*. The wing and tail appear to average slightly smaller than examples of *B. a. anthracinus* from the mainland.

Measurements (in millimeters):

Buteogallus a. utilensis

Four adult ♂ from Isla Utila: wing 347-374 (364); tail 198-209 (204); tarsus 79-81 (79.8); culmen from cere 27-28 (27.4).

One adult ♀ from Isla Utila: wing 365; tail 206; tarsus 78.5; culmen from cere 30.

Buteogallus a. anthracinus

Four adult ♂ (La Ceiba, Honduras, 3; Castalon, Texas, 1): wing 356-390 (377.5); tail 189-218 (208); tarsus 77-82 (79.2); culmen from cere 26-29 (27.8).

Two adult ♀ (Siguatepeque, Honduras, 1; Manatee Lagoon, British Honduras, 1): wing 378, 381; tail 212, 219; tarsus 75, 79; culmen from cere 27.5, 30.

Discussion. A single adult male, Carnegie Museum no. 132,488, collected March 24, 1948 on Isla Guanaja, shows the general overall fuscous color of *utilensis*, but the tips of the feathers of the back, wings, breast and belly are similar to the more intense black of *anthracinus*. The two outermost primaries are more distinctly mottled with gray on their undersurface, and



the secondaries more rufous than in *utilensis*. Size is small, as in *utilensis* (wing, 347; tail, 192; tarsus, 79.5; culmen from cere, 27).

This specimen appears to be an intermediate between *B. a. utilensis* and *B. a. anthracinus*, but with its closest affinity toward *utilensis*. This intermediacy would be expected, since Isla Guanaja is the most easterly of the Bay Island group and is closest to the mainland of Honduras.

The new race differs from *B. a. anthracinus* in a direction opposite to that of *B. a. cancrivorus* (Clark) of the southern Caribbean, which it might be expected to approach on geographic grounds. The latter race is more intensely black than *anthracinus*, and has the greatest development of rufous color in the species; *utilensis*, as indicated above, is less intensely black and shows the minimum of rufous. The somewhat brownish appearance of *utilensis* gives it a superficial similarity to *Buteogallus gundlachi* of Cuba and the Isle of Pines, but *gundlachi* differs from all races of *anthracinus* in the great extent of white on the inner webs of the primaries, the two white tail bands, the brownness of the general ground color, and the more powerful heavy tarsus, toes and claws. Even with the limited material that I now have available, I am inclined to agree with Amadon and Eckelberry (1955: 69) that *gundlachi* should be considered a full species.

It is interesting to note that the distinct ecological niches which Dickey and van Rossem (1938: 122-126) ascribed to *B. a. anthracinus* and *B. a. subtilis* (Thayer and Bangs) in El Salvador parallel those of *anthracinus* and *utilensis* in northern Honduras. On Isla Utila *B. a. utilensis* is confined to the mangrove swamps, as is the case with *subtilis* in El Salvador, whereas *anthracinus* in both northern Honduras and El Salvador merely requires the presence of water, so that as long as there are streams, lakes and swamps, the birds are found from the coastal plains up through the humid jungles to the pine barrens and the deep barrancas of the mountain slopes.

This species was very abundant on Isla Utila, where it was seen around the extensive mangrove swamps. On April 17, 1948, several pairs were observed in an aerial courtship performance which consisted of a pair chasing each other all over the sky for 10 to 15 minutes, ending when the pair suddenly came to rest in a tall tree where copulation took place. A nest was discovered the following day in a tree, 50 to 60 feet from the ground, near the edge of the mangrove swamp. The nest, a bulky affair made of sticks, appeared either to be just completed or to contain fresh eggs, for the pair at once began to whistle as I approached and then flew off. As long as I remained near they continued to circle about overhead until we left the area. The hawks were feeding on crabs and iguanas, both of which were very abundant on the island. The natives refer to the birds as "crab hawks" because of this food preference.

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ART. 23. NOTES ON THE FRESH-WATER SNAIL *LEPTOXIS*
(*MUDALIA*) *CARINATA* (BRUGUIÈRE)

BY JUAN J. PARODIZ

Associate Curator of Invertebrates

Generic position of "*Bulimus carinatus*" Bruguière

The generic name *Leptoxis* Rafinesque 1819, according to Pilsbry (1917: 311-314), must replace *Anculosa* Say 1821, with *Melania praerosa* Say as genotype. Although no species was mentioned with its description, *Leptoxis* has the same validity as *Ambloxis* or *Pleurocera* by the same author. Haldeman in Chenu's "Illustrations Conchyliologiques" (1848) placed the species *dissimilis* Wood (= *carinata* Bruguière) in *Leptoxis*, "supported by figures in Rafinesque's MS. 'Conchologia Ohioensis', possessed by him" (Pilsbry), but Morrison proved that Chenu himself and not Haldeman put the name *Leptoxis* Rafinesque on Haldeman's monograph. The name was correctly used by H. Adams and A. Adams (1858: 307) for *carinata* Bruguière (although these authors created the subgenus *Nitocris**), and by Paetel (1868: 358) who mentioned *Leptoxis carinata* "Anthony". Also Binney (1865: 64) said: "I have not considered it necessary to repeat Mr. Say's description (*dissimilis*) being well known and universally acknowledged to be a *Leptoxis*."

Hannibal (1912: 168), reintroduced the name *Ellipstoma* Rafinesque 1818, with two subgenera, *Anculosa* (type *praerosa* Say) and *Mudalia* (type *carinata* Bruguière) but according to Morrison (1954: 363) *Ellipstoma*, the status of which is uncertain, is not related to *Leptoxis*.

It was proposed by Bryant Walker (1917: 1) to retain the name *Anculosa* which "had general recognition for many years". It is true that almost all the authors used *Anculosa*, and Pilsbry as well as Walker recognized the fact that Rafinesque's works have lacked clarity but, "general recognition" of a name is not a sufficient reason to set aside the nomenclatorial rules and regardless of any discrimination about Rafinesque's works, *Leptoxis* has priority over *Anculosa*.

Goodrich (1932: 39) observed that the radulae in *carinata* and *dilatata* have six denticles, or occasionally eight or ten, in the internal marginals, "this dimorphism [sic] being a characteristic of *Lithasia obovata*." But *Lithasia* Haldeman 1840 is, according to Morrison (1940: 65) the same thing as *Anculosa*, and this author in his later works (1950, 1954), did not mention *Anculosa* or *Lithasia*, but *Leptoxis*; however, Morrison designated *carinata* as the genotype of *Mudalia* Haldeman 1840. The first name used by Haldeman for *Mudalia* was *Anculosa* (*M.*) *turgida* Haldeman which "resembles somewhat *Paludina dissimilis* Say"; in 1940 Morrison used, also, *Anculosa* (*Mudalia*) *turgida* as subgenotype, a species which is the same as *carinata*.

* *Nitocris* H. Adams and A. Adams was preoccupied by Rafinesque 1815 for Hymenoptera. Later this name was used several times: Lepidoptera Guene 1868, Coleoptera Thompson 1858, Oligochaeta Kingbar 1866.

Reaching this point, *Mudalia* results as a subgenus of *Leptoxis*, in the same sense as that of the preoccupied *Nitocris* H. Adams and A. Adams and the correct combination for the species must be *Leptoxis (Mudalia) carinata* (Bruguière).

Genus *Leptoxis* Rafinesque 1819

Type by subsequent designation of Pilsbry 1917: *Melania praerosa* Say

Synonymy: *Anculosa* Say 1821

Anculotus (emm.) Say 1825

Ancylotus Say 1825

Ellipstoma Rafinesque 1818 (in part).

Paludina, *Melania* in partibus speciorum referenda.

Original description: "Différent du *Lymnula*, -for *Lymnaea*-, par test ovale, bombé, à 2 ou 3 tour de spire; ouverture ovale presque aussi grande que le tout; yeux extérieurs. Environ 4 espèces fluviatiles, lacustres et palustres".

Subgenus *Mudalia* Haldeman 1840

Type by subsequent designation of Morrison 1950: *Bulimus carinatus* Bruguière=*Paludina dissimilis* Say=*Anculosa (Mudalia) turgida* Haldeman.

Synonym: *Nitocris* H. Adams and A. Adams 1858.

The following complementary diagnosis combines that of Haldeman and Adams's synonym:

"Shell smooth, thin in texture, labium without enamel" (Haldeman). "Subglobose, whorls angulated, often carinate and inner lip subtruncate or ending in a tubercle" (Adams).

Morrison (1950: 361) separated *Mudalia* and *Leptoxis* as two different genera. The radulae of *Mudalia* show some differences. The rachidium tooth is larger, the internal marginals are more denticulate, and the laterals have three large denticles which are lacking in *L. praerosa*; but these differences in relationship are also very common in other Pleuroceridae, and the radulae in general are mostly of the *Oxytrema* type.

Leptoxis (Mudalia) carinata (Bruguière)

Bulimus carinatus Bruguière. Encyclopedie methodique 6. Histoire naturelle des vers, 2, 1792: 301. Pfeiffer. Symbolae ad historiam Heliceorum, 1842: 113. Catlow. The Conchological nomenclator, 1845: 152.

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- The type locality of Bruguière specimens is unknown, but for its first synonym, *dissimilis*, Say stated that "this species was found by Mr. Thomas Nuttall, during a journey to Pittsburg"; it means, in relation to localities of other synonyms, the southern part of the Susquehanna River.

Shell subconical, body whorl globose or angular, spire short with sides rather flat and apex often decollated by erosion in adults; five whorls when complete; a marginated suprasutural carina often present; surface almost smooth with wrinkles of growth which, in most gerontic specimens, may be strong, rib-like and, occasionally, with fine transverse, oblique ridges on the posterior side, above the umbilical area. Young specimens with strong carinae, 3 to 5 in number, or with only one carina around periphery. Color clear olive-green to horny, although the darkest colors are not the natural colors of the shell, but a deposit of coloring matter; normal clean specimens are always green; many have chestnut spiral bands, variable in number (1 to 5). These bands, when present, are more conspicuous in the interior of the aperture; in specimens without bands, a brown spot behind the columella is often present. Aperture suboval, subrounded, with straight or slightly curved columella which may or not be folded, white or purplish. The border of the lip is always thin and fragile, even in the largest and most solid specimens.

Length 9 to 18.5 mm.; diameter 7 to 12.5 mm.; ratio of length to diameter 1.44; aperture 6-10.5 by 3.5-7 mm.

The most variable feature of the species is the carination, which in the adults became reduced to an almost rounded periphery.

Distribution: Abundant in mountain streams of Atlantic drainage east of the Allegheny Divide, but not present in the Delaware River or beyond. West of the Allegheny Divide it is replaced by *dilatata* Conrad, apparently a very closely related species but, in the opinion of Morrison (1954: 363), the monogenotype of *Anaplocamus* Dall 1895, as a northern representative of the *Io* group.

SPECIMENS EXAMINED

(Numbers in parentheses indicate the Carnegie Museum catalogue numbers.

Figures preceding parentheses indicate number of specimens.)

New York

Broome Co. Binghamton, Susquehanna River. 20 (62.7070)

Pennsylvania

Susquehanna River drainage

Bradford Co. South Waverly, Chemung River. 25 (62.7970)

Bradford Co. Towanda, Susquehanna River. 14 (42.886)

Wyoming Co. Tunkhannock, North Branch Susquehanna River. 26 (62.7971)

Snyder Co. Selinsgrove, Susquehanna River. 13 (62.8140)

Snyder Co. Selinsgrove, Penns Creek. 38 (62.8139)

Juniata Co. Mifflintown, Lost Creek. 50 (7337)

Huntingdon Co. Ardenheim, Raystown Branch Juniata River. 60 (62.7539)

Huntingdon Co. Alexandria, Frankstown Branch Juniata River. 1 (62.7538)

Dauphin Co. Hummelstown, Swatara Creek. 1 (62.32940)

Bedford Co. Mt. Dallas, Raystown Branch Juniata River. 38 (62.7976)

Bedford Co. Bedford. 6 (62.6320)

Cumberland Co. Carlisle, Conodoguinet Creek. 6 (62.8138)

Adams Co. Table Rock, Conewago Creek. 6 (62.8138)

York Co. York Haven, Conewago Creek. 20 (62.8133)

Potomac River drainage

Franklin Co. Scotland, Conococheague Creek. 22 (62.8136)

Franklin Co. Greencastle, Conococheague Creek. 33 (62.7974)

Franklin Co. Waynesboro, East Little Antietam Creek. 18 (62.8135)

Franklin Co. Mercersburg Junction, W. Conococheague Creek. 26
(62.8137)

Fulton Co. Thompson, Great Tonolowa Creek. 32 (62.7973)

Bedford Co. Hyndman, Wills Creek. 52 (62.7975)

Maryland

Washington Co. Hancock, Potomac River. 2 (62.7972)

Allegany Co. Ellerslie, Wills Creek. 25 (62.5711)

West Virginia

Hampshire Co. Romney, South Branch Potomac River. 1 (62.8173)

Hampshire Co. South Branch Potomac River. 16 (62.8307)

Morgan Co. Cherry Run, Potomac River. 30 (62.5710)

Jefferson Co. Harpers Ferry, Shenandoah River. 40 (62.8174)

Hardy Co. Fischer, Keller Island. 3 (62.40753)

Virginia

Shenandoah River drainage

Augusta Co. Waynesboro, South River. 18 (62.8303)

Rockingham Co. Elkton, South Fork Shenandoah River. 15 (62.8316)

Rockingham Co. Broadway, Shenandoah River. 20 (62.8306)

Rappahannock River drainage

Spotsylvania Co. Above Fredericksburg, Rappahannock River. 22
(62.19445)

Culpeper Co. Rapidan River. 15 (62.8310)

James River drainage

Rockbridge Co. Buena Vista, North River. 25 (62.8313)

Rockbridge Co. Lexington, North River. 30 (62.8312)

Rockbridge Co. Calf Pasture, Goshen River. 30 (62.8309)

Chesterfield Co. Swift Creek. 2 (42.887)

Henrico Co. Richmond, James River. 18 (62.19446)

Amherst Co. James River. 10 (62.19450)

Albemarle Co. Charlottesville, Rivanna River. 18 (62.8311)

Campbell Co. Below Lynchburg, James River. 10 (62.19451)

Dinwiddie Co. Petersburg, Appomattox River. 14 (62.19448)

Prince Edward Co. Framville, Appomattox River. 24 (62.19449)

Amelia Co. Mattoax, Appomattox River. 12 (62.19447)

Roanoke River drainage

Alleghany Co. Covington, Jackson River. 25 (62.8171)

Montgomery Co. SW. of Ellington, Roanoke River. 13 (62.29000)

Roanoke Co. Salem, Roanoke River. 18 (62.8314)

Roanoke Co. Roanoke, Tinker Creek. 4 (62.8315)

Roanoke Co. Salem, Mason Creek. 25 (62.8172)

Franklin Co. Rocky Mount, Pigg River. 25 (42.888)

Franklin Co. Gegginsville, Blackwater River. 16 (42.890)

Henry Co. Martinsville, Smiths River. 130 (42.889)

North Carolina

Pamlico River drainage

Halifax Co. Enfield Fishing Creek (seven specimens clear olive-green, without fold, but with 2 to 3 spiral bands and angular or semi-rounded periphery). These are the most southern specimens, undoubtedly *carinata* as determined by Ortmann.

Leptoxis (Mudalia) carinata is a very plastic species, individuals of which show great differences in the same population. Hartman (1874: 84) gave a general idea of the variations in a brief description: "Shell thin, conical, 3-4 whorls, body whorl large more or less carinate in the middle; carina sometimes double or wanting; aperture ovate; columella flattened at base and occasionally toothed; color olive-green or yellow H.12, W.18. Susquehanna and tributaries". Tryon (1866, figures 19-56) figured numerous specimens with many remarkable variations. No further complete description of the species and comparisons of its variations has been made, but some authors have suggested that the differences found in the species, and some names of its intricate synonymy, are probably representatives of different ecological races or subspecies. However, all of these variations have been found in specimens from one and the same locality. The diameter of the shell in proportion to the total length varies in one population from 67 to 79 per cent. The carina is less conspicuous in aged specimens, and those with a single carina or angular periphery are common in medium sized specimens. The bands of color and the fold on the columella can be present in both young and adults or lacking completely. It was not practically possible to take the average of the ratio of length to diameter in each population because, except the youngest, almost all the specimens have the apex very much eroded or decollated and the absolute lengths can not be estimated; to avoid this difficulty I have tried to choose the average specimens of full size in each population observed.

In order to determine all the other variations independent of size proportions (color bands, folds, carina, ribs, etc.), I have set up a diagram of triangular form (Fig. 1). The individuals of this diagram all belong to the same population (Smiths River, Virginia). From 130 specimens of this lot have been selected 45 which represent all the known variations of the species. These are arranged in nine primary series. As the variable characteristics diminish from A to I, the number is gradually reduced in each successive series, and the triangular form of the diagram is the result. Fig. 2 represents the individuals contained in the diagram, as follows:

Series

- A-9. Specimens with five or four carina.
- B-8. Specimens with three carina, progressively less prominent.
- C-7. Specimens with two carina or angular periphery.
- D-6. Specimens with carina almost gone.
- E-5. Angular specimens to almost subrounded periphery, and columellar fold.

- F-4. Angular to subrounded, with ribs of growth.
- G-3. Subrounded to rounded periphery, with or without fold; intermediate specimens with stripes.
- H-2. Rounded periphery, folded, strong ribs of growth; some specimens with stripes.
- I-1. Rounded periphery, strong columellar fold, elongated, with bands.

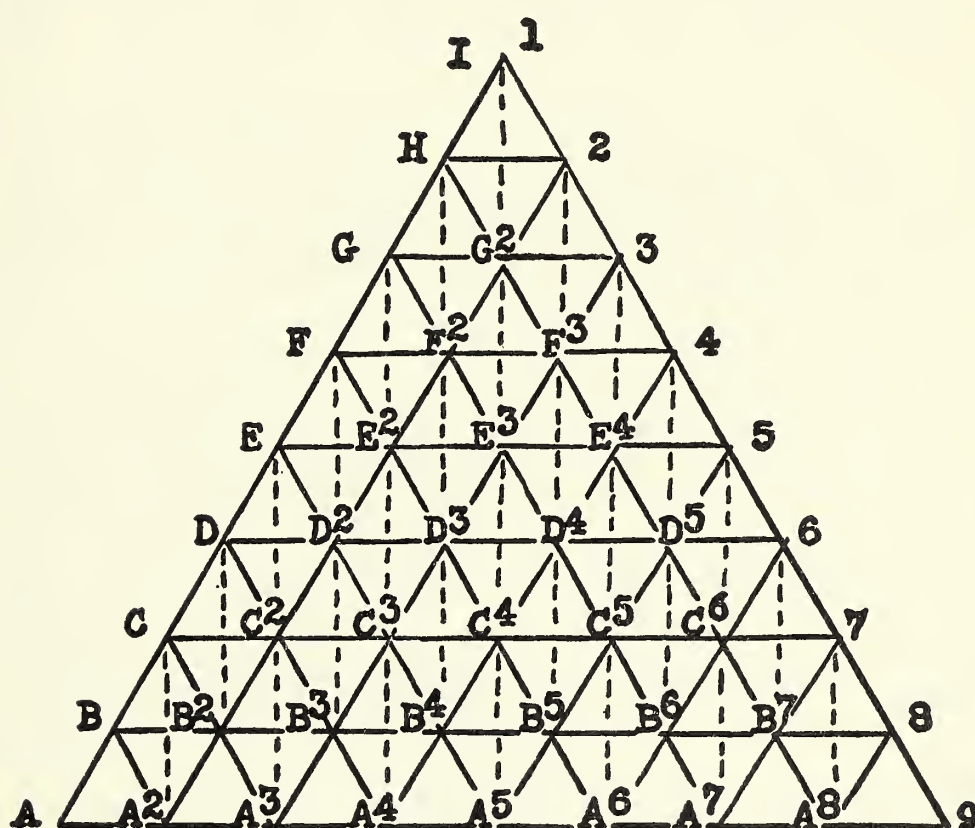


FIG. 1. Diagram for comparison of the variations according to the specimens of Fig. 2.

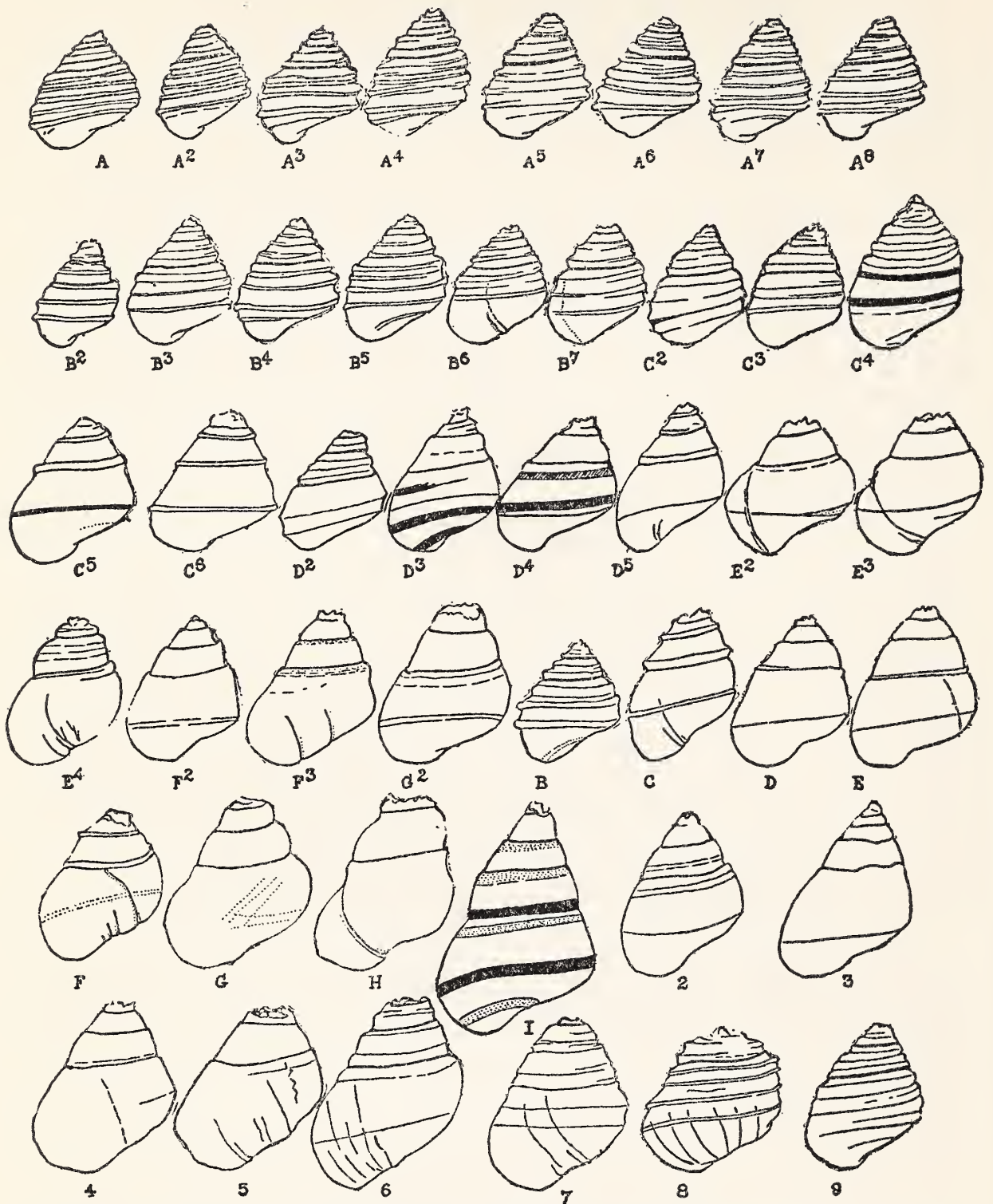


FIG. 2. Variation in specimens of the same population (Smiths River, Virginia). The individuals are numbered according to their places in Fig. 1.

The first individual in each series is the primary or more elemental form of the variation, and the last represents the strongest differentiation in that line and on the other hand they are the more gerontic specimens; the young are placed at the beginning of the lower series. Many other lines of variation may be controlled in supplementary series, for instance, between two or more separate series (vertical G-A⁴, 2-B⁵, etc.), or among a complete number of oblique series (H-A⁸, A³-3, etc.). The diagram allows other combinations to find the immediate relations of any individual; thus F² represents the intermediate of F-G, G-G², G²-F³, F-F³, or F-G², G-F³, G²-E³, F³-E², G-E², G²-E², G-E³ and F-F³, which are:

- F². Small, dark colored, subrounded, without bands, not folded columella.
- E. Similar to E².
- E². Medium sized, angular, clear color, without bands; spot behind columella.
- E³. The same, but dark and with fold.
- F. Medium sized, angular, convex sides, without fold.
- F³. Small, angular, convex sides, without fold, with three bands.
- G. Large, almost rounded, clear color, with fold.
- G². Large, rounded, with fold, dark color, with three bands.

The specimens of series A and B are similar to *canalifera* Anthony (Tryon, 1866, figures 6-7) and others illustrated by Tryon (figures 32-36) from the Potomac, Shenandoah and Roanoke rivers. The extremes of the series B, C, and D, resemble *rubiginosa* Lea (Tryon, 1866, figures 17-18). In the series D and G were found the angular specimens with or without columellar fold or bands (Tryon, figures 25-28, 30, 43, 48, etc.). Also *corpulenta* Anthony seems to be a variation of this species. I did not see forms resembling *canalifera*, *rubiginosa* or *corpulenta* in collections from Pennsylvania, and some authors still consider them as proper forms of the South, different from *carinata*, but among the individuals of the same population from Smiths River, there are forms intergradient between those and *carinata*.

The observations made on the populations from New York to Virginia in different drainages, did not give occasion to separate ecological races or subspecies since, as said earlier, the variations are represented by individuals and not by biotypes. However, a summary of these observations in each drainage may be of value.

Susquehanna River and tributaries. In this drainage was found a larger proportion of average size specimens with equal quantities of narrower and wider ratios of length to diameter. The large-sized specimens are frequent too, most of them without columellar fold and with dark columella. The external color is more uniform olive-green, but there are many darker, and the surface is sometimes rough, with very strong ribs of growth. Strong carina was rarely observed, and the average specimens are almost rounded or angular. Many have spiral brown bands, 1 to 4 in number, or replaced by a dark spot behind columella. Normal aperture.

Potomac River and tributaries. Abundance of smaller, narrower specimens. Columella often white without folds, but in a small proportion with a

tuberculiform tooth. External color clear olive-green; some with rugose surface; many rounded or angular, some carinate; few with 1-3 bands or brown spot behind columella. Ribs of growth may be present but not so strong as those of the Susquehanna drainage. Aperture proportionally smaller, but this characteristic is not constant.

Rappahannock River. Narrower, large-sized specimens with folded columella, rounded periphery, few angular. Many without bands. Normal aperture.

Shenandoah River. Generally narrower and smaller in size. The dark columella may or may not be folded. Rounded or angular periphery. Normal aperture.

James River and tributaries. Medium size with or without bands. In other features they are similar to those of Rappahannock and Roanoke drainage. Carina variable.

Roanoke River and tributaries. Medium size. Columella white or brown, with or without fold. Olive-green, rough surface, periphery rounded, angular or carinate. Bands 1-3 or lacking. Few with ribs of growth. Proportionately larger.

It is interesting to point out that the 1-4 carinae are more noticeable in young specimens than in adults; many of the species described as different were based on specimens without complete development. On the contrary, the tuberculiform fold on the columella is more developed in gerontic individuals. There is a tendency to a more rounded periphery, the roughness of the surface, and stronger ribs of growth in aged specimens. Color bands, colored columella and the spot behind it, are very variable and uncertain characteristics in both adults and young.

Fig. 3 illustrates certain details, and Fig. 4 indicates distribution.

The so-called "*Anculosa dilatata*" Conrad, is very similar in color, but the body whorl is proportionately wider, with broader columella, *never folded* but with an angular expansion on the left; very rarely it shows colored spiral bands. Some southern specimens of *dilatata* from Summers County, W. Va., have greater resemblance to *carinata*, especially with those more elongated specimens from Smiths River (H and I in the diagram). Young individuals of *carinata* have also some similarities to *showalteri* Lea from Alabama characterized by a very obtuse apex and a greater aperture.

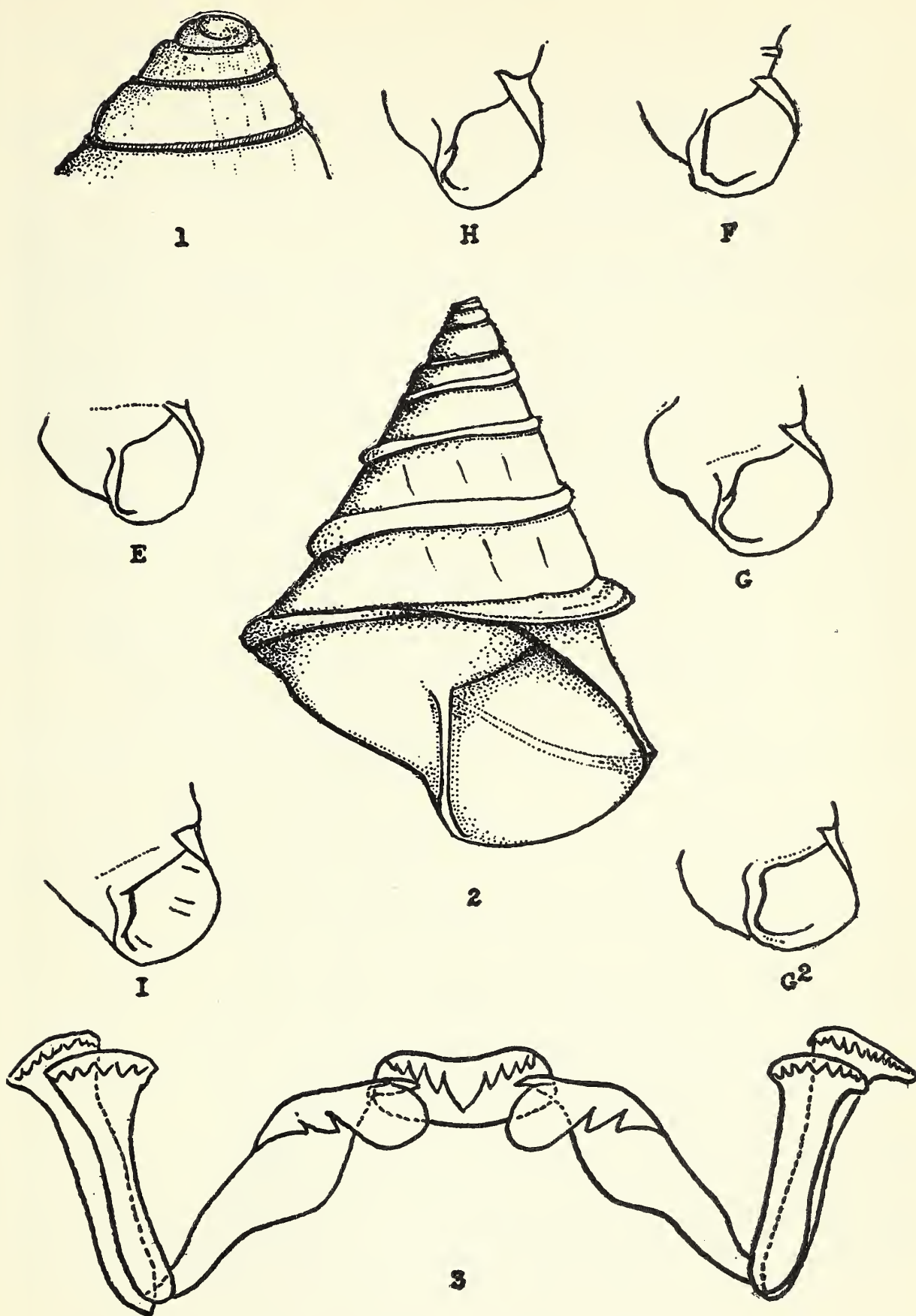


FIG. 3. E-I. Variation of columella (individuals as indicated by letters of Fig. 2).
1. Protoconch in young. 2. Young individual from Smith's River, Virginia.
3. Radulae.

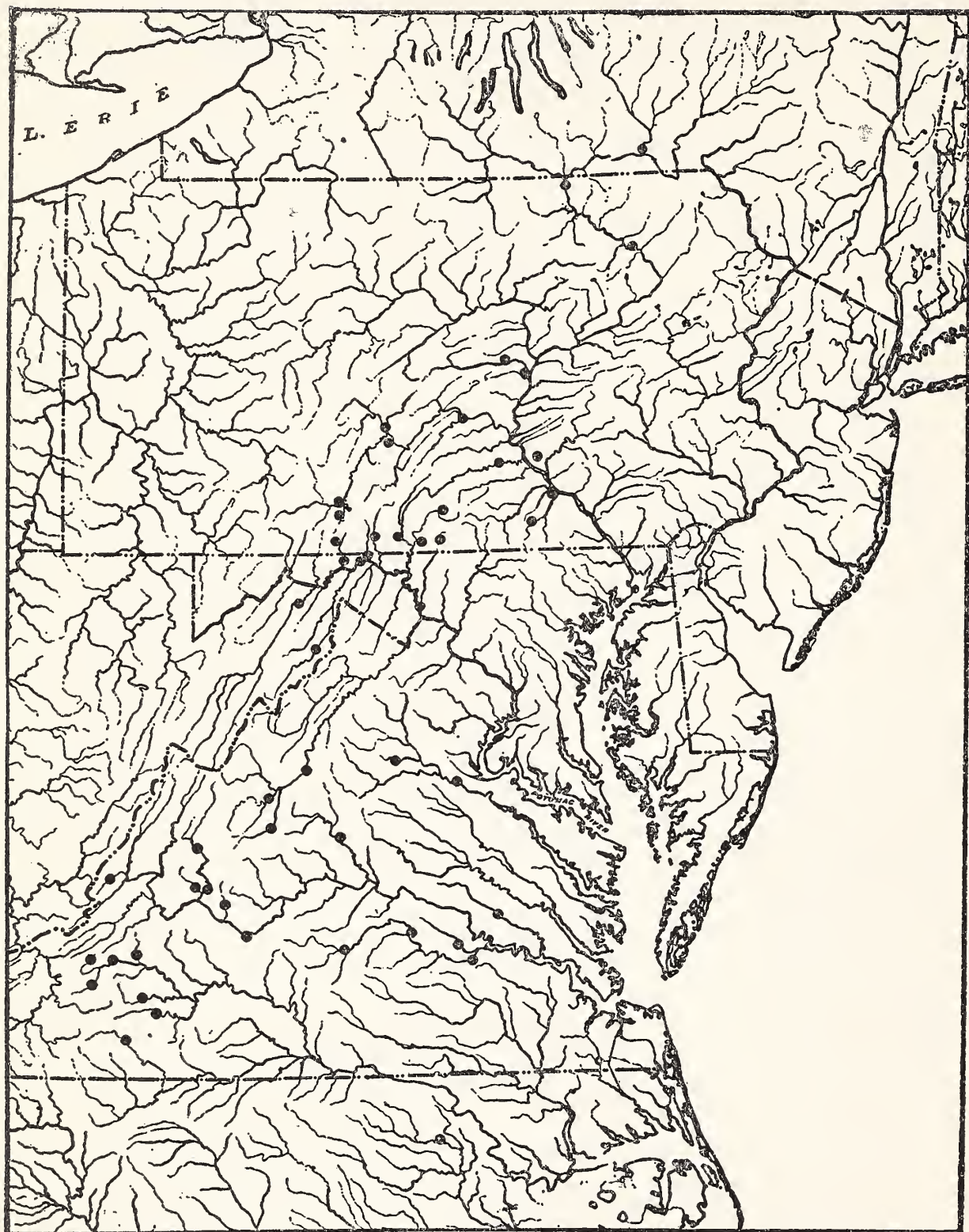


FIG. 4. Distribution.

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